#132 OCTOBER 1987

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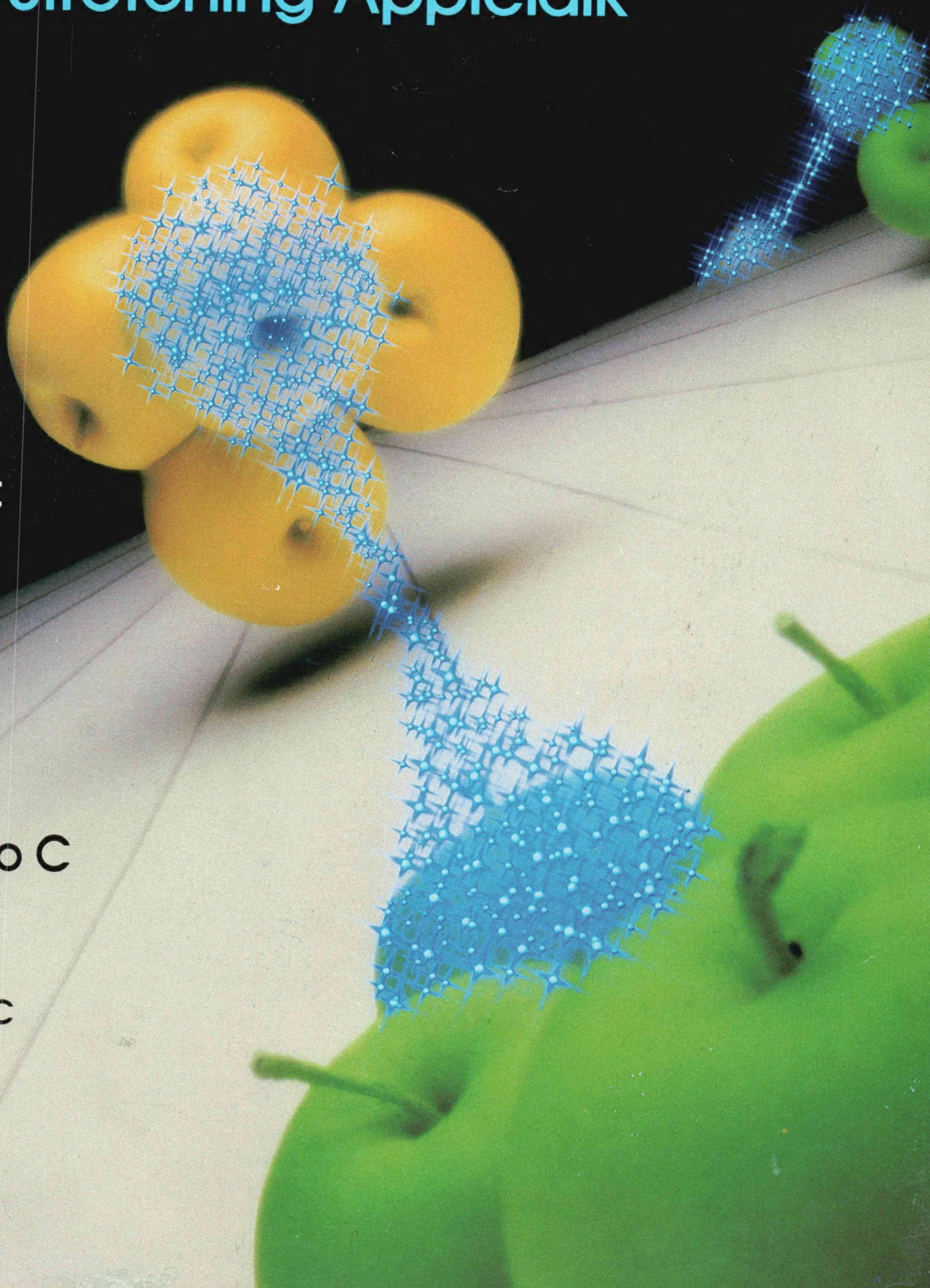
Dr. Dobb's Journal of Software Tools

FOR THE PROFESSIONAL PROGRAMMER

Stretching AppleTalk



Focus on Forth:

Unifying Dialects
Faster Forth
A New Column

Quick C & Turbo C

Languages:

Forth, Pascal, BASIC, C

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DR DOBB'S JOURNAL
132 OCTOBER 1987

bo C: NEW!
erful optimizing
ler ever

Sieve benchmark

	Turbo C	Microsoft® C
Compile time	*2.4*	13.51
Compile and link time	*4.1*	18.13
Execution time	*3.95*	5.93
Object code size	*239*	249
Execution size	*5748*	7136
Price	*$99.95*	$450.00

Benchmark run on an IBM PS/2 Model 60 using Turbo C version 1.0 and the Turbo Linker version 1.0; Microsoft C version 4.0 and the MS overlay linker version 3.51.

Technical Specifications

- ☑ Compiler: One-pass optimizing compiler generating linkable object modules. Included is Borland's high-performance Turbo Linker.™ The object module is compatible with the PC-DOS linker. Supports tiny, small, compact, medium, large, and huge memory model libraries. Can mix models with near and far pointers. Includes floating point emulator (utilizes 8087/80287 if installed).
- ☑ Interactive Editor: The system includes a powerful, interactive full-screen text editor. If the compiler detects an error, the editor automatically positions the cursor appropriately in the source code.
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- ☑ Links with relocatable object modules created using Borland's Turbo Prolog into a single program.
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- ☑ Loop optimizations.
- ☑ Register variables.
- ☑ ANSI C compatible.
- ☑ Start-up routine source code included.
- ☑ Both command line and integrated environment versions included.
- ☑ License to the source code for Run-time Library available.

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BI-1131 A

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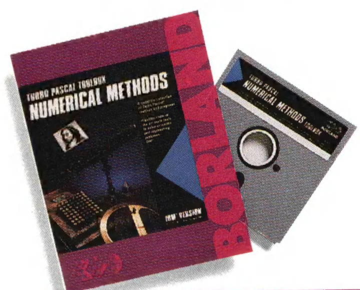
> *Stephen Randy Davis, PC Magazine*
>
> Language deal of the century. *PC Magazine*"



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Garry Ray, PC Week"

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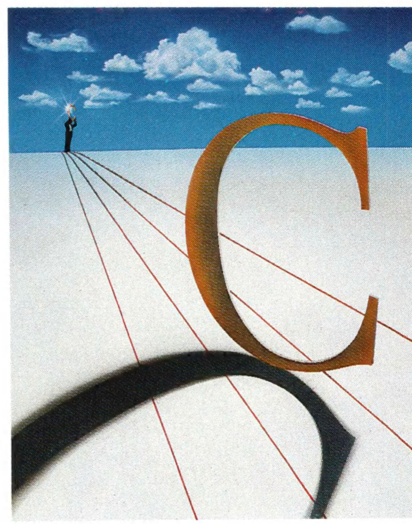

"Turbo C does look like What We've All Been Waiting For: a full-featured compiler that produces excellent code in an unbelievable hurry . . . moves into a class all its own among full-featured C compilers . . . Turbo C is indeed for the serious developer . . . One heck of a buy—at any price."

Michael Abrash, Programmer's Journal

Turbo Basic introduces its powerful new Telecom, Editor and Database Toolboxes

NEW!

Turbo Basic® is the breakthrough you've been waiting for. The same power we brought to Pascal with Turbo Pascal has now been applied to BASIC with Turbo Basic.

Compatible with BASICA, Turbo Basic is the high-performance, high-speed BASIC you'd expect from Borland.

Basically, Turbo Basic is all you need

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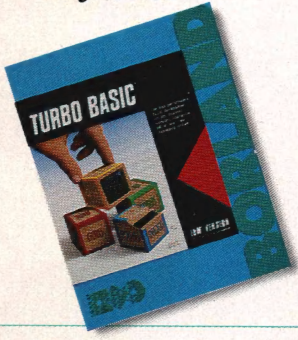
Includes a free MicroCalc™ spreadsheet complete with source code. ***Only $99.95!***



A technical look at Turbo Basic

- ☑ Full recursion supported
- ☑ Standard IEEE floating-point format
- ☑ Floating-point support, with full 8087 (math co-processor) integration. Software emulation if no 8087 present
- ☑ Program size limited only by available memory (no 64K limitation)
- ☑ VGA, CGA, and EGA support
- ☑ Access to local, static, and global variables
- ☑ Full integration of the compiler, editor, and executable program, with separate windows for editing, messages, tracing, and execution
- ☑ Compile, run-time, and I/O errors place you in the source code where error occurred
- ☑ New long integer (32-bit) data type
- ☑ Full 80-bit precision
- ☑ Pull-down menus
- ☑ Full window management

> "Borland has created the most powerful version of BASIC ever.
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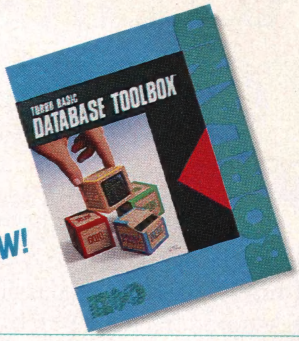

Database Toolbox means that you don't have to reinvent the wheel each time you write new Turbo Basic database programs.

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Source code included.
Only $99.95!

NEW!

Editor Toolbox is all you need to build your own text editor or word processor. Includes source code for two sample editors.

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MicroStar™ is a full-blown text editor with a complete pull-down menu user interface, and gives you

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Now, just $129 and supports Microsoft C 5.0 and QuickC

Blaise puts the Accent on C with C TOOLS PLUS/5.0™

Enhance your Microsoft C programming environment with C TOOLS PLUS/5.0™—a new, quintessential library of C functions. C TOOLS PLUS/5.0 from Blaise Computing Inc. puts a prime accent on quickly building professional applications using the full power of Microsoft C Version 5.0 and QuickC. Now you can concentrate on program creativity by having full control over DOS, menus, interrupt service routines, memory resident programs, printer and keyboard control, and more!

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Continuous refinement of Blaise Computing's library products has produced a collection of tools that are unsurpassed for reliability, functionality and ease of use. Built upon the widely acclaimed C TOOLS PLUS, C TOOLS PLUS/5.0 includes such highly-developed features as:

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OCTOBER 1987

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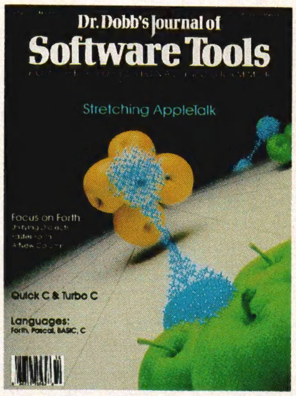


About the Cover

"Apples in space" is just our way of saying that physical distance, be it a hundred feet or a few thousand miles, is no longer an obstacle to linking AppleTalk nodes.

This Issue

Our annual Forth issue introduces a new bimonthly Forth column as well as two ways to increase Forth speed: the first increases execution speed on 68000 machines; the second trims development time for PC Forths. Finally, our cover story looks at how two gentlemen from Dartmouth have expanded AppleTalk into a "nonlocal" area network.

Next Issue

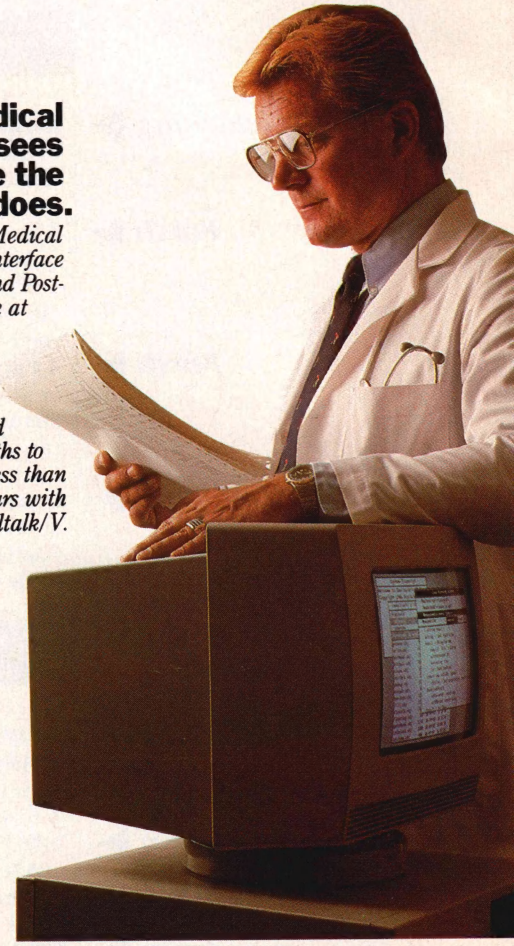
November's *DDJ* features a graphics theme, and we're not talking about just another pretty face here, folks. Programming PC graphics is the focus, and we'll approach it from several different language directions.

This ad is for people who don't know where to find Smalltalk. Or why.

Today, the single most important emerging software technology is OOPS, object-oriented programming. It's destined to dramatically change the way you use your personal computer. You'll find it doing things you never expected. And by people you never suspected.

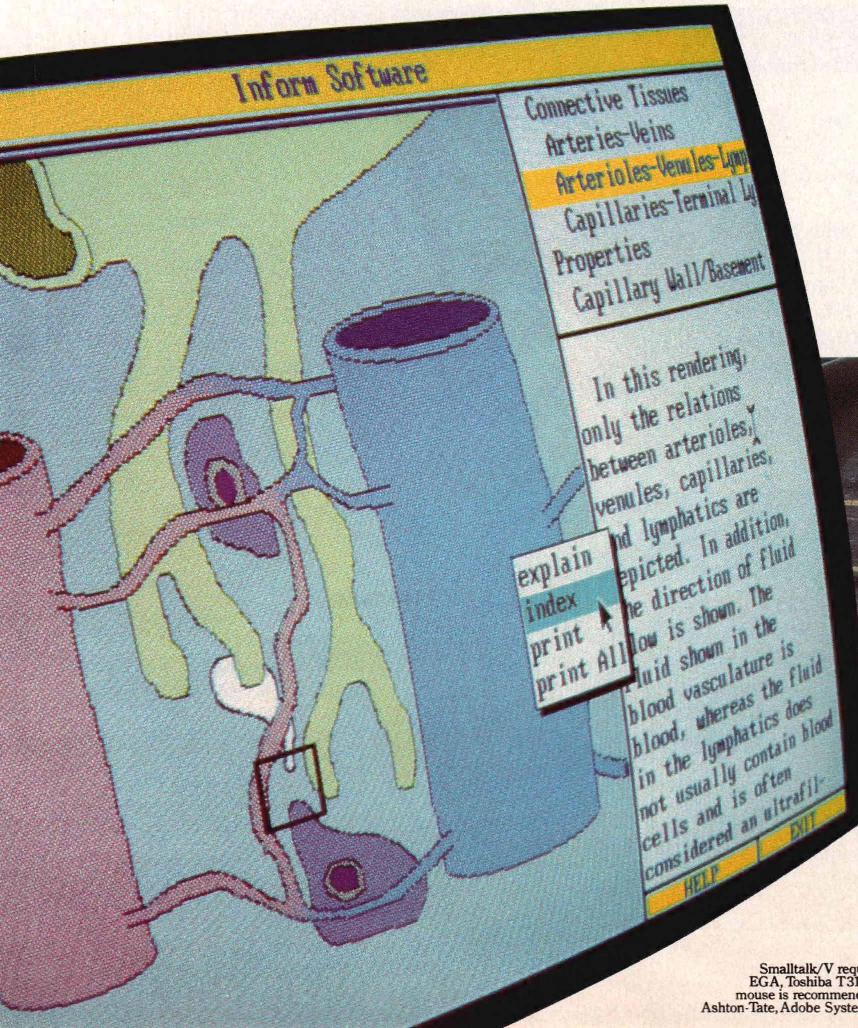
At the UCLA Medical Center, it sees patients before the doctor does.

Mike McCoy, M.D., at the UCLA Medical Center, found that he could easily interface Smalltalk/V with dBASEIII and PostScript. His application, now in use at the Clinic, turns a functional status questionnaire on each new patient into a laser printed, advisary analysis for the doctor to review prior to seeing the patient. A program like this would normally take a specialist months to produce. It took Dr. McCoy less than 100 hours with Smalltalk/V.



In an emergency room in Vancouver, it's saving lives through animation.

What if a medical textbook could come to life? What if it could show the effects emergency treatment might have on patients? And do it all through moving pictures? These thoughts led Folkstone Design, Edge Training & Consulting, and Inform Software in Vancouver, B.C., to create the first animated, interactive textbook for emergency room technicians and in-training paramedics. They found Smalltalk/V could easily facilitate a combination of text, color graphics and animation to illustrate various physical processes and the results of medical intervention.



It's working on Florida's freeways.

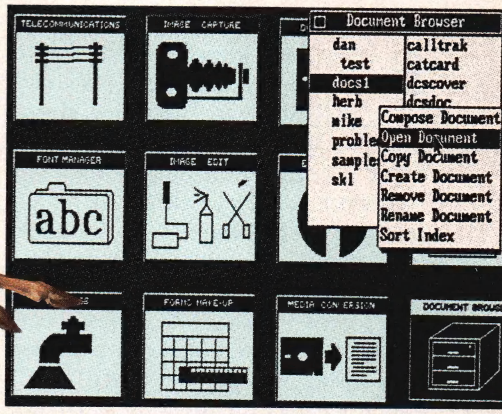
Running on IBM's new PS/2, a Smalltalk/V application developed by Greiner Engineering's Mike Rice, lets highway engineers create highly sophisticated graphic analyses of any proposed reconstruction. So now, instead of having to deal with a gridlock of Federal and State regulations, engineering specifications and endless calculations, an engineer can quickly explore alternative design strategies using a mouse, windows and VGA color graphics.

Smalltalk/V requires DOS and 512K RAM on IBM PC/AT/PS or compatibles and a CGA, EGA, Toshiba T3100, Hercules, or AT&T 6300 graphic controller. A Microsoft or compatible mouse is recommended. Not copy protected. dBASEIII, PostScript and PS/2 are trademarks of Ashton-Tate, Adobe Systems and International Business Machines Corporation respectively.

You can find it in space.

On a project commissioned by NASA, Dr. Christine Mitchell at the Georgia Institute of Technology, chose to use Smalltalk/V as an integral part of a new man-machine interface. The application, written in Smalltalk, continually monitors the commands of the Satellite Network Operator, the state-of-the-network and the overall mission plans.

To NASA, Smalltalk/V means real-time. Real OOPS. Real results.



It's tracking white-tail deer on the Barrier Islands of Georgia.

Dr. Lee Graham, a National Park Service ecologist chose Smalltalk/V to write an application to help manage the white-tail deer population on the Barrier Islands of Georgia. Dr. Graham found that Smalltalk/V, with its visual interface and class structure, is a perfect tool to graphically simulate the complex, ecological interactions of natural systems.

It's making headlines in Arizona.

When Digital Composition Systems sat down to build an electronic typesetting system, they had three major requirements. It had to have the most advanced user interface. It had to be fast. And, it had to be able to turn untrained personnel into high quality typographers. Of all the languages in the world, they chose Smalltalk/V. The result is the Signature Series, recognized and reviewed by The Seybold Report. It's now marketed by Digital Composition Systems and one of the largest digital typesetting firms in the world, Varityper AM International.

What thousands of people have found is OOPS.

Object-Oriented Programming (OOPS) is programming by defining objects, their inter-relationships and their behavior. Objects can represent both real-world entities like people, places, or things. They can also represent useful abstractions such as stacks, sets and rectangles.

OOPS models the way you think and the way things really are. It lets you solve problems by breaking them down into easily handled sub-problems and their inter-relationships. The solutions you come up with can be re-used to solve new problems. Ultimately, OOPS makes programming a simple, logical process of building on the work of others.

Why thousands more are finding their way to Smalltalk/V.

First of all, Smalltalk/V makes OOPS easy.

It's also fast. In fact, it's the fastest OOPS programming available on a PC.

And it's easy to learn. It comes complete with a tutorial that's the best introduction to OOPS available.

Smalltalk/V also has a few other features worth noting. Like a user-extendable, open ended environment. Source code with browser windows for easy access and modification. A huge toolkit of classes and objects for building a variety of applications. A sophisticated source-level debugger. Object-oriented Prolog integrated with the Smalltalk environment. And bit-mapped graphics with bit and form editors, just to name a few.

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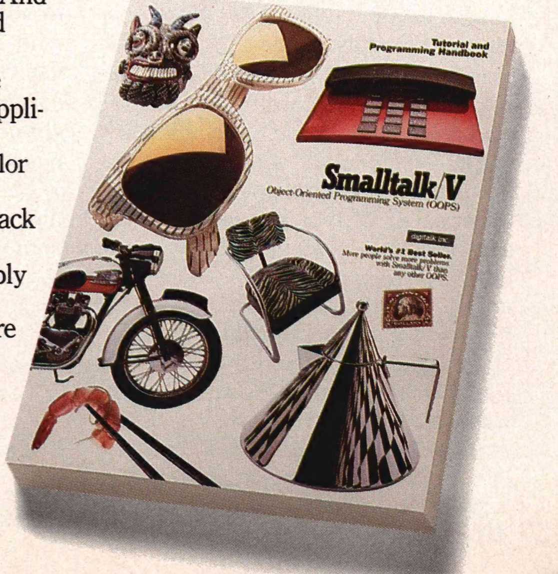

*Now that you've found us, write us. Tell us some of the great things you're doing with Smalltalk/V. You could be in our next ad.

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EDITORIAL

Lebensraum and RAM

Since the beginning of the micro revolution, *DDJ* readers have been plagued with memory shortages. To be sure, our perception of what constitues "enough" memory has been subject to almost constant revision. In the heyday of the S-100 bus, the introduction of 16K dynamic RAM cards was an exciting development. Now just about everyone in the PC realm is complaining that G40K of RAM simply isn't enough room for all their software Déjà vu.

A few years ago, the folks at Lotus and Intel got together and came up with a way of expanding the amount of memory in a PC beyond the 640K barrier. Before long, Microsoft had gotten into the act, and we had a formal spec: the Lotus/Intel/Microsoft Expanded Memory Specification (EMS). The EMS was admittedly a kludge, but bank-switched RAM was better than no RAM at all.

Given the nature of the market, it was inevitable that some people wouldn't be all that thrilled with some of the limitations of the LIM version. Before long an AST/Quadram/Ashton-Tate coalition produced the Enhanced Expanded Memory Specification, a superset of the original plan.

Mercifully, developers weren't asked to deal with any more versions than these two.

Of course, not everyone was happy with the limits of the EMS and the EEMS. There were still some rough edges in the standards, some confusion in the minds of programmers as to which standard to write for, and that annoying upper limit of eight megabytes. And with the growing realization that IBM's PS/2 line isn't going to instantly make all the older DOS machines obsolete, the importance of hardware and software that maximizes the performance of DOS machines has begun to take on a new importance.

And this is where we have good news to report. Recently the folks at Lotus, Intel, and Microsoft announced a new version of the EMS. Rather than yet another departure in standards, Version 4.0 of the Expanded Memory Standard is a superset of both previous standards and the result of cooperation between the vendors.

Representatives from other companies were present at the press conference announcing the new version. People from AST Research were there, as you might expect, but other companies, such as Ashton-Tate, Borland, and Symantec, were also represented. It was particularly gratifying to see Terry Myers of Quarterdeck Systems announcing products that would take advantage of the new standard at the same time the standard was announced. (At long last, the EMS will support multiple processes.)

Although it may seem at times that we here at *DDJ* can only flame when we hear names such as Lotus, Intel, and Microsoft, that's not really the case. We'd like to take this opportunity to commend the folks at AST, Intel, Lotus, Microsoft, and the other companies involved for cooperating in the new EMS standard. In particular, Microsoft deserves praise for making good on its pledge not to abandon the millions of PC users who aren't going to abandon DOS for OS/2. The older machines will continue to need new, innovative software, and this cooperative EMS effort will ease the burdens of both users and programmers. Indeed, the only question I had after the press conference was "Why only 32 megabytes?"

Tyler Sperry

Tyler Sperry
editor

Dr. Dobb's Journal of Software Tools
FOR THE PROFESSIONAL PROGRAMMER

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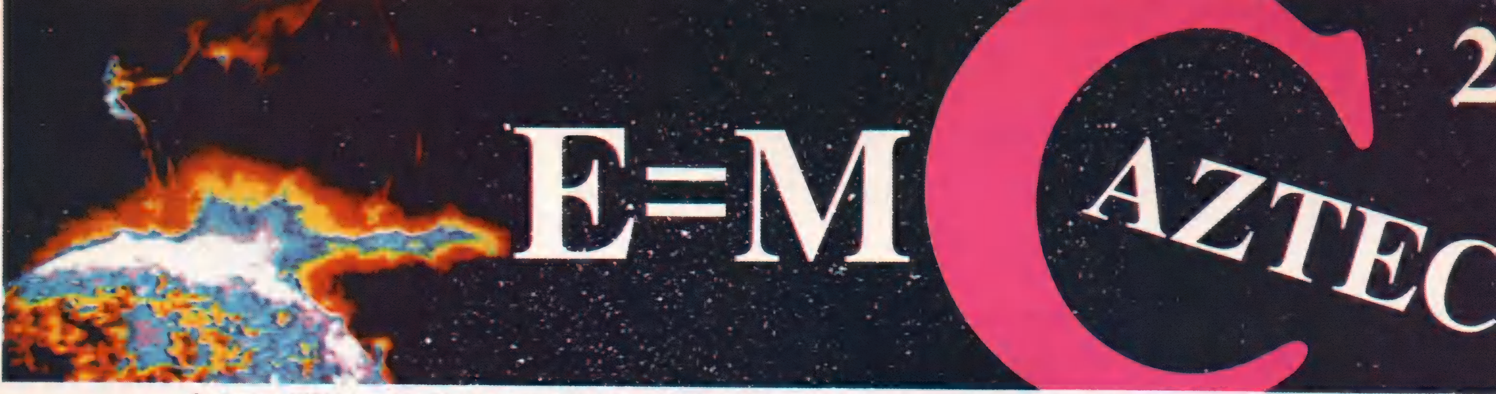

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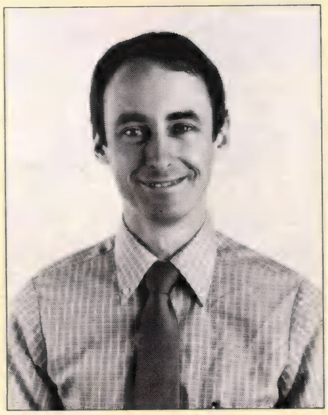
RUNNING LIGHT



In my first column I confessed to not being much of a language zealot. Though I do enjoy playing around with Forth, I don't have the religious fervor that seems to afflict so many Forth enthusiasts. I will, however, also confess to not being able to deny myself the pleasure of baiting C enthusiasts about how wonderful Forth is so that I can watch their faces turn all those pretty colors. (Forthians aren't the only people who can be fanatic about their programming language.) I will even, on occasion, dirty my hands with a program written in Turbo Pascal or QuickBASIC.

From what I've learned in talking with *DDJ* readers, this isn't all that unusual. Most of you seem to be rather fond of programming in C on MS-DOS machines, but that isn't all that surprising given the current popularity of C and *DDJ*'s history of exploring C compilers from the inside out. In fact, one of the distinguishing characteristics of a long-time *DDJ* reader is familiarity with a variety of languages.

It is with this in mind that we put together every issue of *DDJ*. Thus, you'll find this issue—our "annual Forth issue"—not completely overrun with articles written about Forth. True, there a couple of rather good Forth articles, and we're introducing a new Forth column, but there is plenty more here as well—and our coverage of Forth doesn't begin and end with this issue.

Because I'm in a confessing mood, I'll unpack another: I am a man without a number. I am neither a sixer nor an eighter. I learned to program in machine language on the RCA 1802 (I learned enough to know better—please don't send in any 1802 articles) and moved through CP/M to MS-DOS along with the rest of you. I've seen enough machines and nifty software to realize that short of having a basement with a Cray and about a dozen other computers hooked up to a magic terminal, there's simply no way I'll ever be satisfied with a single machine.

Which brings us, in a not entirely circuitous manner, to this month's lead article. Rather than putting off Rich Brown and Steve Legitt's piece on extending the AppleTalk network until January's "annual 68K issue," we're printing it now for those of you who (like me) don't want to wait for a good article. As you might expect from my comment on numbering, this is hardly the last Mac article you'll be seeing in *DDJ*. In the future, who knows? A column on Mac topics? We'll see.

One last thing. No Running Light would be complete without soliciting reader feedback and articles. What are you interested in reading in 1988? We're looking for more articles on debugging, object-oriented programming, and real-time programming for the first quarter. Call me at (415) 366-3600 or catch me on line and tell me what you'd like to see in the magazine.

Tyler Sperry

Tyler Sperry
editor

ARCHIVES

Ten Years Ago In *DDJ*

"When faced with the choice of paying $100 or more for a piece of commercial software without source code, or a freebie with source code, most people will try the freebie first. If it doesn't work out, they can always buy the commercial product.

"Personally, I wouldn't want a piece of sourceless software as a gift, let alone pay money for it. Sooner or later, I want to make modifications. Without the source code this can be a real hassle. It can be a hassle even with the source code and full documentation. . . .

"By refusing to sell source code, vendors are cutting down their sales potential. The practice can't prevent anyone from making a tape copy for his buddy down the street, nor can it keep anyone from using a disassembler to see what makes a program tick. Yet some vendors are so secretive they won't even sell you a Basic manual unless you buy the whole package and sign a non-disclosure agreement. Who needs that kind of trip?" *Jim Day, letter to the editor,* DDJ, *October 1977.*

Elegant Efficiency

"Computer programming is a form of art, far from being a discipline of science or engineering. For any specified programming problem, there are an infinite number of solutions, entirely dependent upon the programmer as an artisan. We can, however, rate a solution by its correctness, its memory requirement, its execution speed, and other qualities.

"For some applications, best is whatever is shortest and fastest. The only way to achieve this goal is to use the computer with an instruction set optimized for the problem. Optimization of the computer hardware is clearly impractical because of the excessive costs.

"Thus, one would have to compromise by using a fixed, general purpose instruction set offered by a real computer or a language compiler. To solve a problem with a fixed instruction set, one has to write programs to circumvent the shortcomings of the instruction set.

"The solution in FORTH is not achieved by writing programs but by creating a new instruction set in the FORTH virtual computer. The new instruction set in essence becomes 'the' solution to the programming problem." *C. H. Ting, "Formal Definition of FORTH,"* DDJ, *February 1982.*

DR. DOBB'S JOURNAL of COMPUTER Calisthenics & Orthodontia
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You've seen the ads: Datalight challenges Microsoft. Our C compiler expert Richard Relph saw the ads and sent for Datalight's compiler. What he found when he began to test it must have given him mixed feelings. For the past two years Richard has been involved in developing the DDJ suite of benchmarks for C compilers. The Datalight compiler flattened those benchmarks, making them worthless.

With the apparent glut of C complier suppliers vying for the MS-DOS market, it was only a matter of time before one of them decided to step above the crowd and provide a reliable optimizing C compiler. Datalight beat all others to the punch by delivering such a compiler February of this year. (Dr. Dobbs Journal, August 1987)

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DR. DOBBS, August 1986

"This is a sharp compiler!... what is impressive is that Datalight not only stole the compile time show completely, but had the fastest Fibonacci executable time and had excellent object file sizes to boot!"

COMPUTER LANGUAGE, February 1986

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- Multiple memory model support
- Interrupt handling in C
- Make utility
- EZ editor
- DLC one step compiling
- Start-up code for 8086
- ROMable library (without hidden MS-DOS calls)
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- Source level debugging on the target system
- View source code as it executes on target
- Access local variables
- View 8086 machine internals

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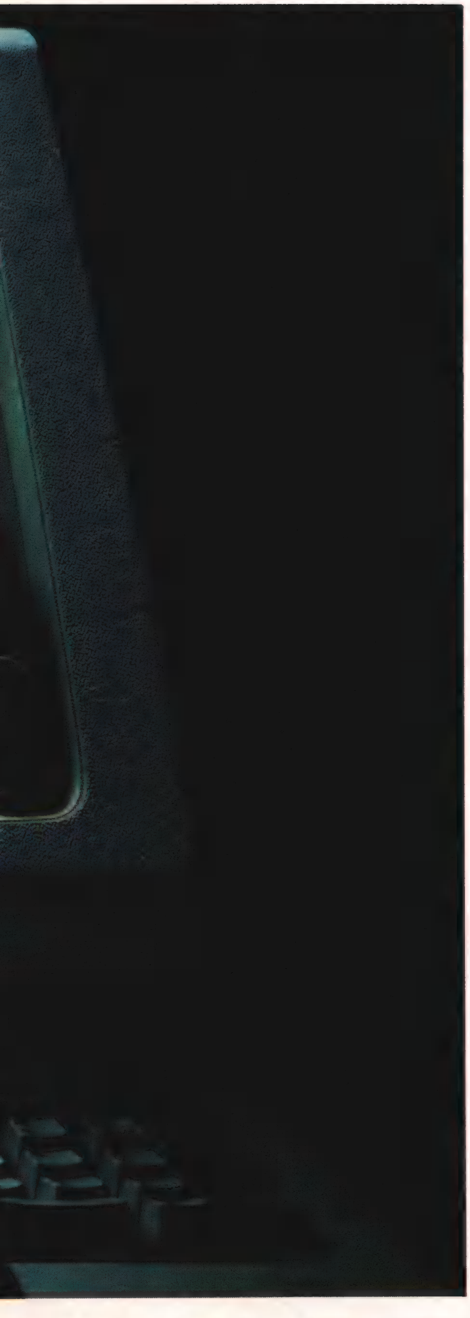

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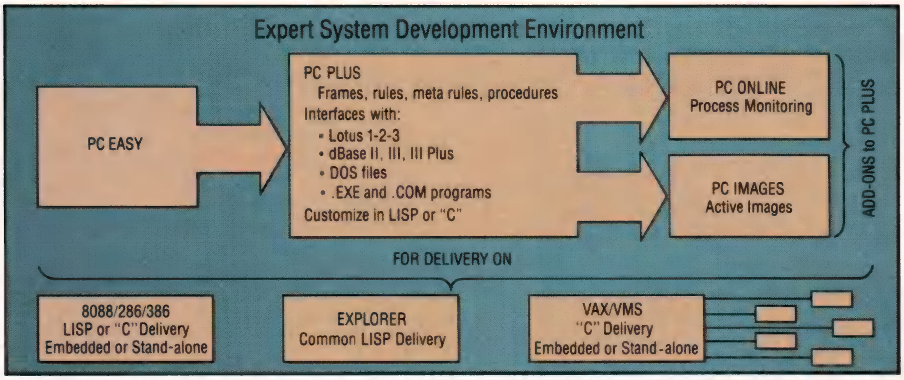

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TEXAS INSTRUMENTS

LETTERS

A-to-D Conversion

Dear *DDJ*,

I have some comments on John Musselman's article on page 22 of the June issue. All but the first are Complaining Songs, but remember the first *is* first because it's important. I would not complain about details if I didn't like what the author was doing.

1. The circuit in Figure 1 and the insight that it suffices to digitize voltages are delightful. I can only gasp "Nifty!" and "Why didn't I think of that?"

2. The proof of a pudding, however, is in the eating. I want to see calibration data before I believe it's so easy. Some of the problems I anticipate are saturation effects when the unknown voltage gets close to the limits (for example, 0 or +5 volts) and interrupt latency jitter. I don't know how your TMS7000 works, but the specs for my Z80A seem to say that the delay from the interrupt signal to start of the interrupt routine can vary by 5.8 microseconds, depending on what the CPU is doing when the interrupt comes. I guess it could be even longer if other interrupts were active. The averaging process would tend to wash out any effect, but I would try some worst-case tests to see if it causes any trouble.

3. Whenever the input voltages at the comparator are not (nearly) equal, the Out bit stream will be solid 1s or 0s until the voltages become equal. These bits don't belong in your average, so you must—if there is any chance that an average will be asked for before comparator voltages get equalized—delay accumulation of the average until at least one transition 0<==>1 comes down the bit stream. I don't see this safety feature in the software, but it would be needed, for example, for a time multiplex application, in which a sequence of voltages was measured one after the other. When John Musselman proposes a digitizer using only one I/O bit, I am impressed, but when I see it needs more than a second per channel in time multiplex, I start to nod off.

Why not go at it like this? Let the time constant, RC, be much longer than the period, P, between interrupts (for example, 1 millisecond). Assume you know the voltage, $V(T)$, on the capacitor at time T, when an Out=1 period begins. By Ohm's law the current into C is $I(T)=(H-V(T))/R$, where H is the logic 1 voltage. Because $P<<RC$, the total charge flow during this interrupt period is very nearly $P(H-V(T))/R$, and the voltage at T+P is, to first order in P, $V(T+P)=V(T)+P(H-V(T))/(RC)=V(T)(1-P/(RC))+HP/(RC)$. If, instead, a 0 is sent out, $V(T+P)=V(T)(1-P/(RC))+LP/(RC)$, where L is the logic 0 level.

In words, the voltage on C at the end of a period is the average of the voltage at the start of the period, weighted by $1-P(RC)$, and the voltage Out, weighted by $P/(RC)$. Repeating the procedure, you can calculate $V(T+2P)$ and so on.

The "old" voltage is always multiplied by $(1-P/(RC))$. This is a "forgetting factor" because it is close-to-but-rigorously-less-than 1. (The arithmetic needs some thought lest truncation error obscure this fact.) So, even if you use a wrong number for $V(T)$, the error gets squashed down by one forgetting factor at each interrupt; $V(T)$ and the actual voltage on C get ever closer. But you don't need to guess $V(T)$: initialize Out to logic 0 before loading the program, and start interrupts at T=0 with the (excellent) assumption that $V(0)=L$.

Meanwhile it's still true that a bit stream transition 0<==>1 marks a voltage crossover at the comparator inputs, so the current value of $V(T)$ is already a good estimate of the unknown voltage; nothing is gained by averaging for another second.

Arthur's entry into software piracy was marred somewhat by his lack of professional discretion.

Thus, in a given setup, John Musselman's method (usually called the boxcar average) and the forgetting-factor average converge to the same result on a DC voltage. But when the boxcar algorithm is ready to start measuring, the forgetting-factor algorithm already has the answer.

The pudding is still pie in the sky. I will not be able to run the necessary tests soon, but I hope that someone else will do so and send me the conclusions.

R. W. Hartung
408 Orchard
East Lansing, MI 48823

Curses

Dear *DDJ*,

Thanks to Allen Holub for his article on curses [C Chest, July 1987]. Last year I, too, needed a curses package to assist in

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(continued from page 12)

porting code between my PC and Unix, so I ended up writing my own. Since then, my package has been expanded significantly (it now provides almost full Unix System 5 compatibility). After receiving several requests for it, I decided to distribute my package (now called PC Curses) as shareware. The package is compatible with Microsoft C 4.0 and includes small- and large-model libraries. If any *DDJ* readers are interested in obtaining a copy, they can do so by sending me one 5¼-inch floppy along with a mailer, return label, and postage (or $5). Readers outside the U.S. should write for information.

Just a few comments/clarification about the article. After complaining about the missing *vsprintf* function, Holub may be happy to hear that *vsprintf* is beginning to appear on various Unix systems (I know that Unix System 5 has it). His comment about using *nl* (instead of *nonl*) seems logical, but Unix curses encourages the latter; moreover, some implementations of Unix curses fail to work properly unless *nonl* is specified. The comment that "... the *refresh()* command only works under the real curses if all windows are subwindows of *stdscr*" is incorrect if it is referring to subwindows created by *subwin()*; I suggest that readers forget they ever read that sentence. Also, Holub made several other comments about subwindows that are incorrect or confusing, and I suggest that anyone using other versions of curses consult the documentation (or code) for more information.

Jeff Dean
710 Chimalus
Palo Alto, CA 94306

Educatin' Programmers

Dear *DDJ*,
I wish to comment on the letter from Neil Pignatano published in your July 1987 issue.

I agree with Mr. Pignatano's assertion that mathematical reasoning is the best paradigm for passing on critical analytical skills to students of computer programming and is certainly superior in this regard to classical languages, as suggested by Allen Holub in his Viewpoint of April 1987.

I most stringently disagree, however, with the point Mr. Pignatano makes next—that there are enough "text editors, database managers, and so on." I believe that the era of truly productive productivity programs is just beginning to emerge and that it is precisely this field that will offer the most challenges and opportunities for programmers in the future.

Mr. Pignatano's views on "electronic desk" software are well known (to his coworkers), but I feel that he is missing out on the possibilities that are continually offered by new developments in hardware technologies; Neil may be content using TECO for his text editor, but I certainly am not!

Mr. Pignatano, as a physicist and a scientific programmer by profession, perhaps does not appreciate the degree to which difficulty of use and obtrusiveness (I might say "pig-headedness") of most currently available software tools inhibits the application of computer solutions to many tasks in business, education, and even technical environments. Unless text editors, database managers, and spreadsheet software begin to respond in consistent and predictable (to the new and occasional user) ways, microcomputers will fail to reach a significant fraction of their potential markets.

Naturally, this belief of mine leads me to conclude differently from Mr. Pignatano on the place of scientific programming in the education of programmers. Rather than the strong emphasis that Mr. Pignatano would have it given, I feel that the overhead intrinsic in the explanation of scientific problems for computer solution make them more appropriate for only occasional use in computer science curricula. I maintain, rather, that scientists of all sorts should be given a strong background in computer programming techniques that they will be able to apply to the endeavors of their own disciplines—a point on which I sense that Neil Pignatano and I can agree.

Martin Veneroso
1646 Latham, #10
Mountain View, CA 94041

VM/RUN Update

Dear *DDJ*,
Your readers may be interested in the following updates to Richard Relph's review of VM/RUN from Softguard Systems [see the July 1987 issue]. The February version, which he reviewed, has been superseded by Release 1.10, which is now available.

The 7 to 15 percent penalty in execution time has been totally eliminated. The problem was caused entirely by diagnostic code that kept the "global exact" flag on at all times. This resulted in instruction fetch degradation. Subsequent benchmarks (with test problems provided by your reviewer) have shown comparable results between the VM/RUN environment, which runs at CPL 3, and Phar Lap's, which runs at CPL 0.

Full directory path support is now available. Support files no longer have to be in the current directory, and the number of files has been reduced.

Significant improvements have been made in application load times. Large-scale applications of ½ megabyte in size are typically loaded in about 5 seconds on a Compaq Deskpro 386.

Finally, let me say that, with the addition of a symbolic debugger and new features, such as the capability of calling 8086 code from a 386 program and vice versa, the VM/RUN environment offers software developers a powerful tool for the creation of 386 applications.

Ken Williams
Softguard Systems Inc.
2840 San Tomas Expy., Ste. 201
Santa Clara, CA 95051

The Problem Is Architecture

Dear *DDJ*,
Frank Albe's letter in Ray Duncan's July 1987 16-Bit Software Toolbox column doesn't get to the point about the computer language controversy. The problem is not with the languages but with the computer architectures that (do not) support them.

Computers are integer manipulators with simple decision-making capabilities. But the world is not com-
(continued on page 144)

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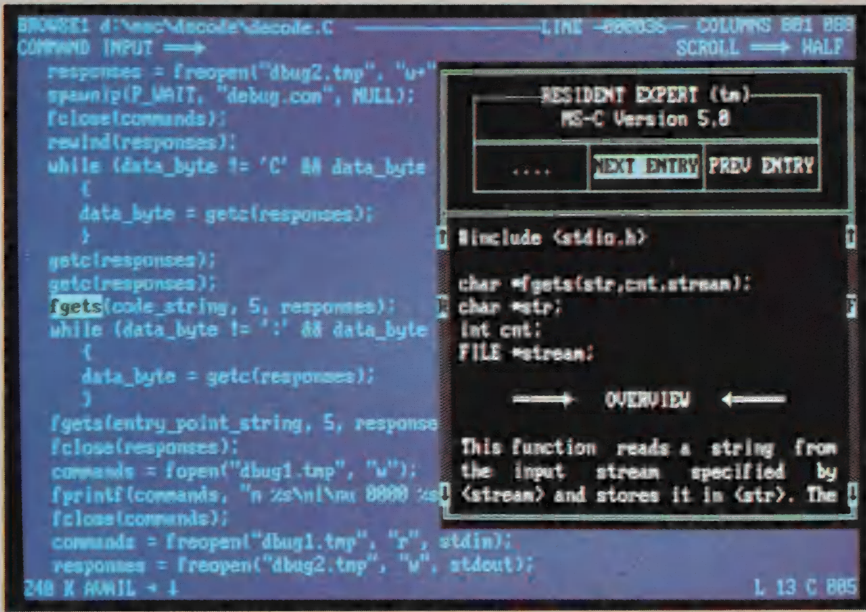

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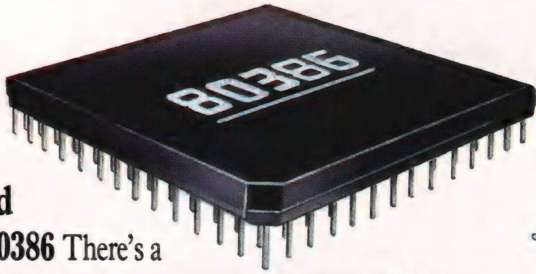
A Number of Reasons A Number



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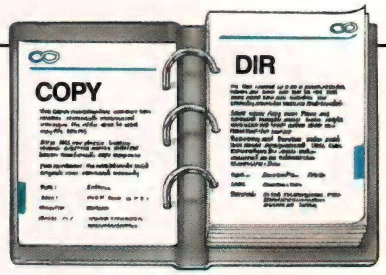

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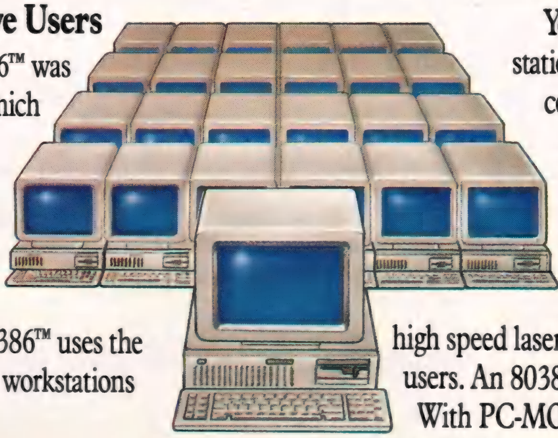

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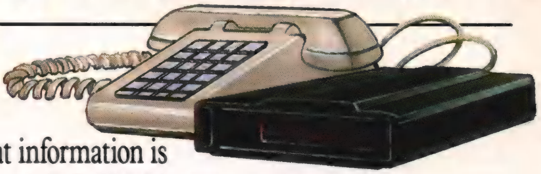

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Async AppleTalk

by Richard E. Brown and Steve Ligett

The design and implementation of an RS-232 enhancement to the AppleTalk protocols

For most users AppleTalk appears to be nothing more than an expensive cable. Actually, it's much more. It's a complete family of data communication protocols designed to allow Macintoshes and other computers to share peripherals and resources. Although the initial AppleTalk service provided a printing connection between a Macintosh and an Apple LaserWriter, these days there are literally dozens of products, including other high-quality output devices and disk or file servers, that take advantage of this 230.4-kbps link between devices.

Async AppleTalk, a software application developed at Dartmouth College, was implemented to expand the potential of this network by allowing AppleTalk devices to be connected over an asynchronous (RS-232) link. The software provides low-cost, remote access to AppleTalk devices and works with nearly all AppleTalk applications.

The first step in designing Async AppleTalk was to define the necessary protocols. A protocol is a set of rules that two or more parties (human or computer) use to conduct orderly discourse. A protocol might, for example, involve two computers negotiating to send a file between them. The conversation could be as simple as that illustrated in Figure 1, page 20. A real protocol would have to specify what would happen if computer B couldn't take a file that big, or if it already had a file named FRED, or if it wasn't saved correctly at the end. But you get the picture—a few more rules could make the scheme watertight.

Richard E. Brown and Steve Ligett, Kiewit Computer Ctr., Dartmouth College, Hanover, NH 03755. Rich is manager of special projects at Dartmouth. He has been writing communications software for seven years and is a member of the IEEE and the ACM. Steve is an engineer in the special projects group of the computing services department at Dartmouth. He writes software for personal computers and designs and builds hardware for Dartmouth's local-area network.

If you were designing the program to implement this protocol, you would like the code to be about as simple as the problem definition. The top-level code should implement the rules mentioned earlier: it shouldn't have to worry about each little mishap that might occur anywhere in the transmission chain. Consequently, you would design this simple file transfer protocol as a network layer and delegate to another layer the responsibility for detecting errors, retransmitting corrupted messages, or sending messages around a network.

Network layering brings to data communications the simplicity that structured programming brings to software. Using layers designers can isolate issues and design solutions for each of the separated areas—for example, code that detects transmission errors solves a very different problem from code that implements the file transfer protocol discussed earlier.

Layering also allows substitution of equivalent services by a different implementation. The link access protocol (LAP), for example, is generally responsible for sending sequences of bytes (frames) on a wire. Different LAP software and/or hardware can use different kinds of wire. The standard AppleTalk Link Access Protocol (ALAP) layer uses twisted-pair wire. Async AppleTalk replaces that wire with a modem or RS-232 link. Another LAP replacement is an AppleTalk to Ethernet converter—it uses the 10-Mbps link to deliver AppleTalk datagrams. All three LAP layers have their place; none of them could have been done if the highest-level code had to deal with all the successive details of data transmission.

Each network layer provides a well-defined service to a

higher-level client. The client then communicates with a peer across the network. The effect is that peers appear to be talking directly to each other, as if the lower layers weren't there at all. Each layer specifies the means of communicating with its peer—the protocol—and the service it will provide to its clients.

Peers communicate by asking a lower layer to perform a service for them. The lower layer can, in turn, invoke still lower layers to do more work. The lowest layer—the physical layer—is the electronics that sends and receives the bits across a link. At the other end, each layer, starting at the lowest, passes the received data up to its client until the messages reach the peer of the originator.

Another concept in networking is the onion-skin principle. When a layer has data to communicate with its peer, it passes the data to the next lower layer. That layer adds its own information (called a wrapper) and passes the message to the next lowest layer, and so on. When the message gets to the bottom (physical) layer, it is actually transmitted. Each peer at the other end verifies any information contained in the header, removes the corresponding wrapper, and passes the resulting data up to its client—thus, the analogy to the layers of an onion. In the earlier file transfer example, the file transfer layer might send data to a layer that guarantees delivery of the information it was given. This layer could wrap routing information around the message and pass it on to the LAP layer to be sent out on the wire. Figure 2, page 20, shows these transformations.

There is an interesting symmetry in the transmit and receive algorithms. Data to be transmitted is passed down through subroutine calls from one layer to another until it is finally transmitted on the link. Just the opposite sequence occurs when a frame arrives in a computer. The receiver accepts characters until it gets a full frame. If the frame is good (CRC OK, proper length, and so on), the receiver makes a subroutine call to the next layer with the data as a parameter. Depending on how the software was set up, that layer may make further subroutine calls to its next higher layer until the message arrives at the final recipient.

For a detailed and quite readable explanation of networking, take a look at Tanenbaum's *Computer Networks*.

The AppleTalk Protocols

Each protocol of the AppleTalk family performs a specific function. The AppleTalk Transaction Protocol (ATP), for example, specifies how multiple blocks of data (a transaction of, say, eight disk blocks) can be reliably transferred between nodes (that is, Macs) on a network. The Name Binding Protocol (NBP) specifies how to convert a (text) name to a (numeric) network address. The full details of the AppleTalk protocol family are available from *Inside AppleTalk*.

Both ATP and NBP rely on the ability to send a single message through the network, possibly directing (routing) the message through multiple links. The Datagram Delivery Protocol (DDP) specifies how these messages are routed. Another protocol, the Routing Table Maintenance Protocol (RTMP), describes how to maintain tables of routing information.

All AppleTalk protocols rely on the ability to send a frame of data (an orderly sequence of 8-bit bytes) to a neighbor node. The AppleTalk Link Access Protocol (ALAP) specifies the rules for access to the twisted-pair bus, which connects devices on AppleTalk. Just as with a telephone party line, AppleTalk devices must cooperate to keep their messages from interfering. ALAP uses a three-way exchange to minimize the time wasted by collisions. The initiator of the frame listens to see if the bus is in use; if so, it waits a random amount of time and retries. If the bus is idle, the initiator sends a request-to-send (RTS) frame to the intended recipient. If the recipient is prepared to handle the data, it responds with a clear-to-send (CTS) frame. If the initiator receives the CTS, it then sends the data.

If two devices begin to transmit simultaneously, their

(continued from page 19)

RTS frames will collide, garbling both. Their recipients will not receive the RTS correctly and will not respond. Each initiator will fail to receive a CTS, wait a random amount of time, and then retry the transmission sequence. By waiting a random interval, one of the initiators will retry first and will probably succeed.

A final (and very important) point: notice that ALAP does not guarantee correct delivery of a frame. A transmission error could garble a frame; when that occurs, the recipient simply discards the frame as if it had never arrived. How does the data ever get through? Higher layers (ATP or NBP) establish rules for acknowledging messages that must be delivered.

An AppleTalk Implementation

In late 1983, Dartmouth College recommended that the freshmen entering in the fall of 1984 purchase Macintosh computers. It also decided to expand its campuswide data network to support communications in the students' rooms. At that time, Dartmouth had a network of 1,800 terminal ports (asynchronous, RS-232 hard-wired and dial-up ports) served by approximately 40 network nodes (minicomputers) that were located in the basements of academic and administrative buildings. A user at any terminal could connect to any host computer as well as to the library's on-line card catalog, a campus events calendar, or other off-campus networks.

Over the summer of 1984, AppleTalk support was added to the network. Immediately, the number of nodes was more than doubled (to a total of 95) to support the dormitories. The dorms were wired with 2,600 AppleTalk outlets, one plug per pillow. We decided not to retrofit all the async ports to AppleTalk as it would have been prohibitively expensive.

We also developed a terminal emulation program, called DarTerminal, which works across this AppleTalk network to all the host computers. DarTerminal acts as a VT-100 terminal, a TEK10 (4012) graphics terminal, and a distributed screen editor, in which the Macintosh acts as a screen manager for a back-end host editor (now available on the DCTS, VAX/VMS, and Unix systems). DarTerminal also offers simultaneous terminal sessions, cut-and-paste transfers between sessions, and file transfers of entire Macintosh documents.

Unfortunately, in that one stroke, we rendered obsolete the 1,800 asynchronous ports located in the college's academic and administrative offices. Of course, the ports still worked, but over time, as people in those offices bought Macs, they couldn't get the benefits of AppleTalk that we had already provided to the students. This caused some real frustration because faculty couldn't use the same tools as their students. Staff wanted to use a terminal program that was tuned to the students' computing environment. As network maintainers, we wanted to use the multiple sessions to troubleshoot network problems from home (instead of driving to the computer center on cold winter nights . . .).

Computer A		Computer B
Take a file called FRED of length 123456	-->	
		<-- OK.
Here it comes.	-->	
<much data flows>	-->	
That's all. Save it.	-->	
		<-- OK.
Thanks.	-->	

***Figure 1:** Two computers negotiating to send a file between them*

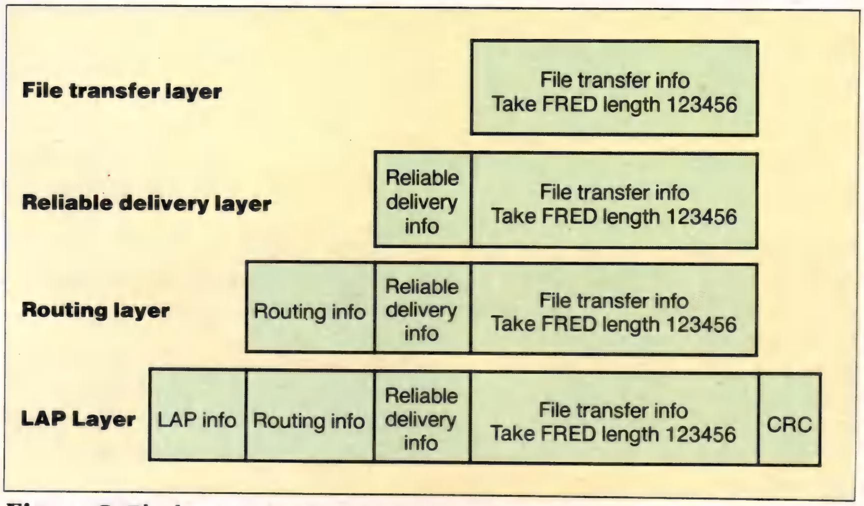

***Figure 2:** The layer onion skin*

There was no off-the-shelf way to make the async ports of the network deal with AppleTalk frames. Yet we felt it was important to let people use DarTerminal over their RS-232 ports. One solution would have been to make an "Async DarTerminal" that ran directly on an async port or modem. This might have worked, but it would have been troubled by flow control (does XOFF mean stop sending, or is it just another data character?) and we would have had problems maintaining two versions of the program. Furthermore, it would only have solved the specific problem of DarTerminal; other AppleTalk applications such as printing and file sharing wouldn't have been able to exploit that solution.

Instead, we chose to send AppleTalk frames over an async link. To distinguish it from Apple's standard link access protocol, we named it Async AppleTalk Link Access Protocol (AALAP). AALAP frames contain all the information conveyed in the 230.4-kbps frames. Furthermore, AALAP provides exactly the same software interface to the higher AppleTalk layers (DDP, NBP, and so on) in the Macintosh. In this manner, the layers above AALAP are "fooled" into thinking there is a 230.4-kbps link in

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(continued from page 20)

place.

Installing the Async AppleTalk Driver

Conventionally, a Macintosh application needing AppleTalk services checks to see if the AppleTalk driver is installed, and if it is, opens it. This offers us two options for installing Async AppleTalk on a disk: providing a way to open Async AppleTalk before an application checks to see if AppleTalk is open or replacing the standard AppleTalk driver so that an application will open ours instead. The simpler method is to replace the standard AppleTalk driver with our driver (in the system file). Then, when an application opens AppleTalk, Async AppleTalk comes up.

There are a few problems with using this scheme, however. Ordinary AppleTalk networks are permanently wired, whereas Async AppleTalk connections are usually temporary, over hard-wired or dial-up lines. The user may need to connect some cables, turn on a modem, or dial a phone to initiate a connection. In addition, Async AppleTalk must provide a way to reestablish a connection if a line is disconnected and to hang up the phone when finished. Finally, we wanted users to be able to use the same disk with standard AppleTalk and Async AppleTalk, and it isn't possible to have two AppleTalk drivers in the same system file.

Instead, we chose to write an Async AppleTalk installer as a desk accessory. Desk accessories are simple to write, and they can also run concurrently with applications. This lets users start up Async AppleTalk within MacWrite—for example, to access a LaserWriter—rather than having to remember to start it beforehand or forcing users to quit MacWrite, start up Async AppleTalk, and then reenter MacWrite.

The User Interface

A user runs the Async AppleTalk installer by selecting it from the Apple menu. The installer presents a window (see Figure 3, below) containing several controls and a status message display. First is a set of speeds, from 1,200 to 19,200 bits per second. To the right of this are four buttons that the user can click: Start, which loads and initializes Async AppleTalk (and can even dial the phone if necessary); Cancel, which terminates the desk accessory without doing anything; Hangup, which disconnects the phone and closes any AppleTalk driver; and Help, which describes what the installer is and how to use it.

Below those controls is a status area that displays the state of AppleTalk (installed, not installed, and so on) or messages from the installer. At the bottom of the window are controls for the auto-dialer. If the Auto-Dial check box is checked, the installer runs a program to dial the phone, using the phone number in the box, before making a connection. The user can enter a phone number before clicking the Start button.

A user starts up Async AppleTalk by selecting the installer from the Apple menu. When the dialog window appears, the user chooses a speed, checks Auto-Dial and enters a phone number if desired, and clicks the Start button. The installer then loads and opens the Async AppleTalk driver, dials the phone if requested, and negotiates for a network address. If all is well, the installer displays the message "Async AppleTalk Installed," saves the speed and phone settings, and terminates. If errors occur in loading the driver, the desk accessory displays a message and allows the user to correct the problem and try again. Common problems are loose cables, a modem that is turned off, an incorrect telephone number, or the other end is down. The user can exit from the desk accessory by clicking the Cancel button if the problem can't be corrected.

Because the installer desk accessory (DA) saves the settings of successful connections, the user usually only needs to select the desk accessory and click the Start button to start Async AppleTalk.

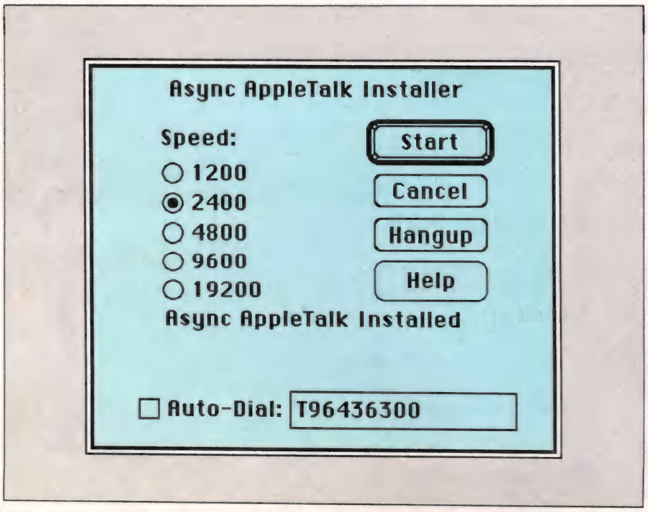

Figure 3: *The Async AppleTalk installer window*

Explanation of the Code

On the Macintosh, AppleTalk is implemented as a set of drivers. A driver is a group of routines that isolates an application from an I/O device by presenting a standard software interface. Because drivers aren't directly linked to an application, an alternative driver can easily be loaded in place of the standard code.

Each of the AppleTalk protocols is implemented as a group of subroutines (for ATP, NBP, DDP, and LAP). When an AppleTalk application requests an AppleTalk service, such as an ATP transaction, the ATP code prepares one or more messages. For each message to be sent, the ATP calls a routine (let's call it *DDPWrite*) to prepare a datagram. The *DDPWrite* routine finally calls a routine (*LAPWrite*) that actually sends the message out on the wire. Now the Async AppleTalk code comes into play. We took the source for standard AppleTalk and rewrote the *LAPWrite* routine to send the characters out on an async link instead of at 230.4 kbps. This produced a driver that was completely transparent to application programs. Our terminal emulation program, file sharing, printing, and other network services all operate unchanged over Async AppleTalk.

AALAP Environment

A low-memory variable (*AbusVars*) at address *$2D8* points to the local variables that Async AppleTalk needs. By convention, the AppleTalk code places this value in register

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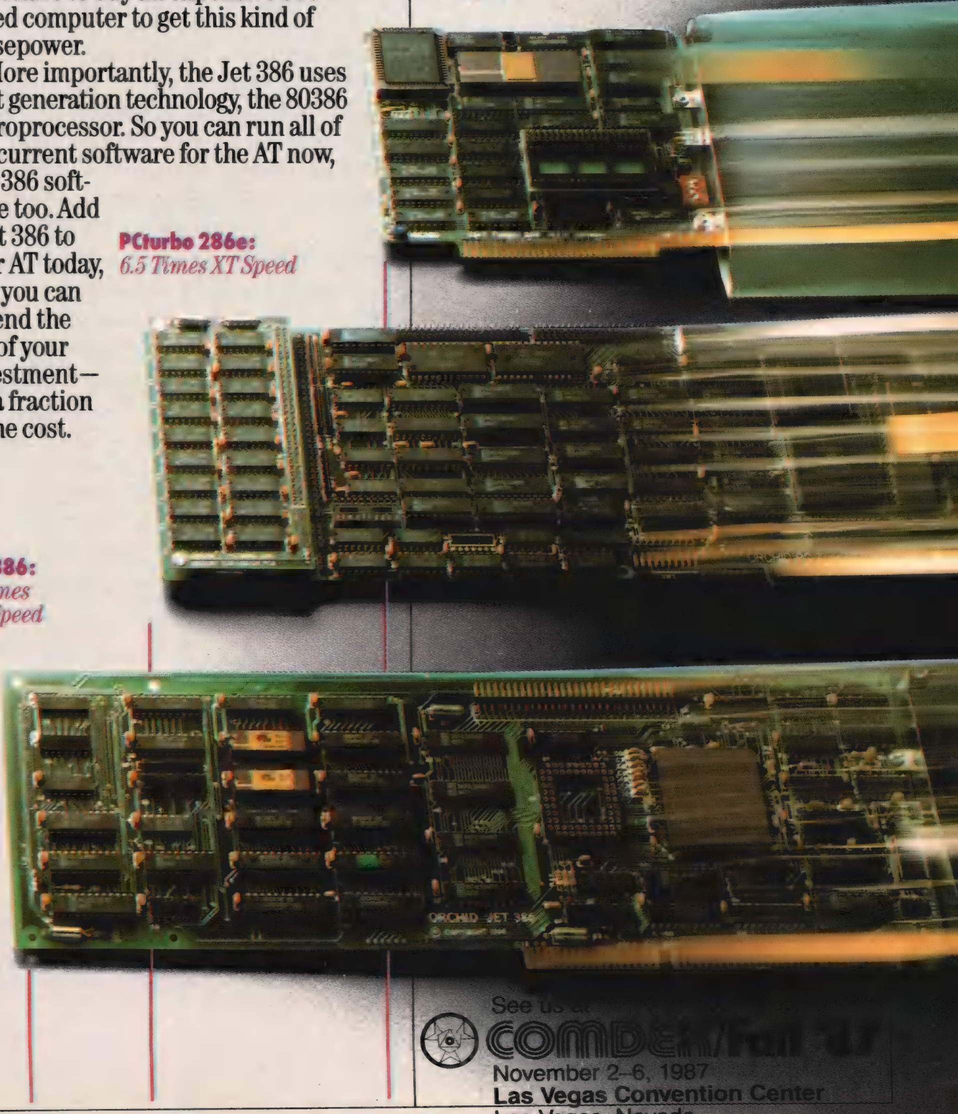

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(continued from page 22)

A2 so that variables are at offsets from *A2*.

The Macintosh uses the (Zilog or AMD) 8530 Serial Communications Controller (SCC). This chip is capable of both async or synchronous transmission. Other serial chips (8250, 1602, and so on) also have the functions required for Async AppleTalk.

There are five important sections to the listings: sending a frame (*LAPWrite* and the transmit interrupt handler), receiving a frame (the receive interrupt handler), the CRC algorithm in 68000 assembly language and Pascal, the port A polling procedure, and miscellaneous support routines. (Listing One begins on page 60.)

Sending a Frame

Each time a frame is to be sent, the driver calls the *LAPWrite* routine to set up certain variables and send the first character of the frame. After that, the transmission is interrupt-driven—each time a character has been completely transmitted, the SCC interrupts the CPU. The interrupt handler sends another character and returns to the application.

LAPWrite is complicated by the fact that it must send frames "asynchronously"—this allows the initiator of the frame to continue without waiting for a long I/O operation, which is important because many seconds may elapse between the start and end of a frame. The device manager is responsible for queuing operations for drivers. It doles out tasks (say, to transmit a frame) one at a time. If an operation can be completed immediately, or if an error is detected, control returns immediately to the device manager.

When an asynchronous operation, such as transmitting a frame, cannot be completed immediately, control returns to the code that originally called the device manager. When the operation completes, the driver returns control to the device manager, which may initiate another operation. For more information about this scheme, refer to *Inside Macintosh, Volume II*.

LAPWrite uses a description of the frame called a write data structure (WDS). The WDS contains one or more segments of data to send as a single frame. Its format is a series of length-pointer pairs that describe each segment to be sent (see Figure 4, below). The length is a (16-bit) word, and the pointer is a (32-bit) pointer to the first character of the segment. Several length-pointer pairs can be concatenated in the WDS, with the final segment being followed by a word of 0.

Before sending a frame, *LAPWrite* first validates the frame by checking that the length is less than 600 data bytes.

Next, *LAPWrite* checks to see if there is currently a frame being transmitted. If so, it checks that it is an IM or UR frame (it returns an error otherwise), saves the WDS of the new frame in *qWDSptr* (the "queued WDS"), and returns (see accompanying article on page 25). If a frame is not being transmitted, *LAPWrite* updates the *PollProc* pointer (described later).

Finally, it ensures that the link is still up by checking that a valid frame has been received within 30 seconds. If not, *LAPWrite* sends an IM frame. A good response (a UR frame) updates the last-valid-frame timer, and the frame is sent as normal. The lack of a response after 10 seconds results in an alert to the user, who can use the desk accessory to restart the link.

Assuming the link is up, *LAPWrite* calls *SendWDSptr*, which saves a pointer to the current WDS in a variable *tWDSPtr* and then initializes several variables (*EscOut*, *nCRC*, *nFrmChr*) that will be used during the frame transmission. *SendWDSptr* also points the *LAPFetch* pointer at the first byte to send and sets *TxCount* to the length of the first segment. Finally, it sends the first character of the frame (*$A5*, the framing character) to the SCC. The transmit interrupt handler sends the remainder of the frame.

The transmit interrupt handler (*TIntHnd*) is an interrupt routine that is called each time the SCC finishes transmitting a character. This routine sends the next character (by calling *TxNextCh*) and cleans up before returning from the interrupt. If no character was actually sent (the previous character was the last one of the frame), then the transmit pending bit is reset so that no more interrupts will arrive. In any case, *TIntHnd* resets the highest interrupt under service (IUS) so that other interrupts can come in.

TxNextCh picks the next character of the frame to send, advances *LAPFetch* (the pointer to the next character to send), and decrements the segment length counter (*TxCount*). It also accumulates the CRC for the frame (by calling *NextCRC*). If escaping is necessary, *TxNextCh* sets the *EscOut* variable to true, leaves *LAPFetch* pointing at the character to be escaped, and sends a DLE (*$10*). If the *EscOut* flag is set, it exclusive-ORs the data character (at *LAPFetch*) with *$40*, increments *LAPFetch*, clears the *EscOut* flag, and sends the character. Notice that escaping always follows CRC accumulation on the transmit side. We will see that unescaping is done before CRC computations on the receive side.

There are several special cases for *TxNextCh*. When the last character of a segment of a WDS has been sent (*TxCount = 0*), it moves to the next length-pointer pair, updates *LAPFetch* and *TxCount*, and continues sending. After all the segments of a frame have been sent,

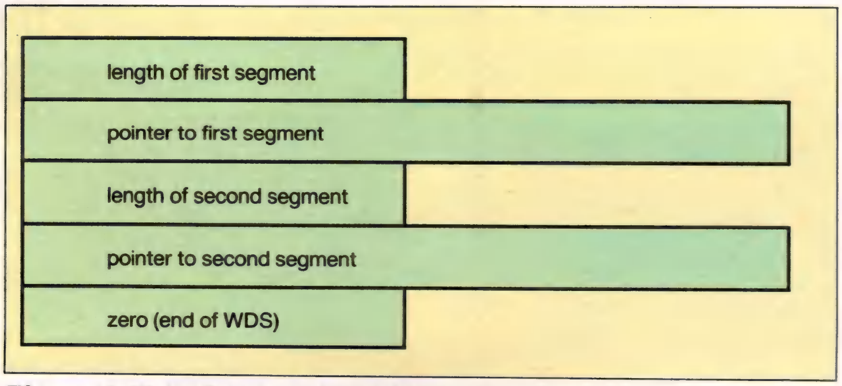


Figure 4: *Write data structure (WDS)*

The Async AppleTalk Link Access Protocol

This section describes the important features of AALAP. The full protocol definition, the Asynchronous AppleTalk Link Access Protocol, Version 1.0, is included on the Async AppleTalk distribution disk.

• AALAP transmits frames of arbitrary 8-bit data to another node across an RS-232 link. It uses 8-bit, no parity transmission with one stop bit. AALAP sends data bytes whose value is the same as certain special characters (that is, flow control characters) by escaping those characters; it sends a DLE (*$10*) and then the desired data character exclusive-ORed with *$40*. Thus the data byte *$13* (XOFF) becomes the two-character sequence *$10 $53*; to send a data byte of *$10* (DLE), AALAP sends the sequence *$10 $50*. The receiver always exclusive-ORs the character after a DLE with *$40* to recover the correct data byte. The characters treated specially are *$10*, *$11*, *$13*, *$91*, *$93*, and *$A5*.

• AALAP marks the beginning and end of each frame with a special "framing" character. This framing character never occurs in the middle of a frame; if AALAP needs to send it, it will be escaped. *$A5* is a good choice because it is unlikely to occur in most data streams and therefore will not have to be escaped often. Placing this character at the start and end of each frame allows easy resynchronization if one framing character has been garbled; the receiver simply waits for two adjacent framing characters, which indicate the start of another frame. Figure 5, below, shows the format of an AALAP frame.

• AALAP detects transmission errors using a cyclic redundancy check (CRC). AALAP computes the CRC (a 16-bit value that depends on all the bits of every character in the frame) and sends this value at the end of the frame. The receiver also computes the CRC on its received data and compares its computed value with the value it received. If the two values are different, an error occurred, and the receiver discards the frame. If the values are the same, then the frame is presumed to have been received correctly.

• AALAP links are full-duplex, point-to-point channels, so there is no contention for the link; standard ALAP has to arbitrate access to the bus to prevent two station's messages from colliding.

• AALAP negotiates the network and node number with the device at the other end of the link at start-up time. The AppleTalk address for a particular device consists of a (16-bit) network number and a (8-bit) node number (for the device itself).

• AALAP uses XON/XOFF flow control. This was a requirement for dealing with host computers that cannot accept large blocks of data at high speed. If AALAP receives an XOFF, it stops sending. It resumes output after receiving an XON. Similarly, AALAP may send an XOFF if it cannot process all the characters that have arrived. Some host computers send flow control characters of either parity (XOFF may be *$13* or *$93*) as flow control; AALAP must honor either.

• AALAP must detect and recover from link failures (such as loss of carrier). There are actually two problems: reestablishing the link and regaining the previous network address. On the Macintosh, a desk accessory (DA) accomplishes both. The DA will dial a selected telephone number, if necessary, and establish the link. If the link fails during a session, the user gets an alert and can then use the DA to restart the link.

• To start the link, the Async AppleTalk installer makes a link (by dialing the phone number and so on) and then gives a command to the AALAP driver to obtain a network and node number (NNN). This is a two-step process. Each end sends an IM (for "I aM") LAP frame that contains its suggested network address; the other end responds with a UR (for "yoU aRe") frame that either confirms that address or makes a different suggestion (see Figure 6, below). The default values for network and node numbers are *$0000* and *$00*, respectively. When zero values arrive in an IM frame, the recipient suggests different (possibly random) values in a UR response. If the recipient of a UR can accommodate the suggested value(s), it switches to use those numbers. When each end has sent an IM and received a UR with the same address, they declare the link to be up.

• Notice that this scheme allows a node to regain its previous network address after being disconnected. When restarting, the node suggests its previous address in the initial IM; if the other end can accommodate that address, it replies with the same values in the UR.

• Whenever a node wants to send a data frame, it checks to see if it has heard from the other end within the last 30 seconds. If not, it sends an IM frame with its current address (to force an immediate UR response). If no response returns, the link can be assumed to be down, and the user gets a warning. If a response arrives, then the original data frame can be sent.

Framing char	LAP type	up to 600 bytes of data	CRC	Framing char

Framing char — *$A5*
LAP type — *$02* DDP; *$86* IM; *$87* UR
Data bytes — arbitrary data
CRC — CRC-16 (see text)

Figure 5: *Generic AALAP frame*

Framing char	IM—*$86* UR—*$87*	Network number (2 bytes)	Node number (1 byte)	CRC	Framing char

Figure 6: *IM/UR frames*

(continued from page 24)

TxNextCh checks *nCRC* to see if it needs to send the CRC. If so, it swaps the bytes of the CRC (so that it will be sent the least significant byte first) and saves them in *CRCBuf*, points *LAPFetch* at *CRCBuf*, sets *TxCount* to 2, and clears the *nCRC* flag. Finally, after the CRC has been sent, if the *nFrmChr* flag is set, a closing framing character will be sent and the *nFrmChr* flag cleared. After the entire frame has been sent, *TxNextCh* looks to see if a queued WDS is waiting to be sent. If so, it resumes transmission with the new frame; otherwise, it informs the device manager that a frame is complete.

Receiving a Frame

The receive interrupt handler (*RIntHnd*) processes arriving characters. Every time a "read data available" interrupt occurs, *RIntHnd* gets a character from the SCC, processes the character as described later, and checks for another character. When there are no more characters, *RIntHnd* returns to the interrupted application.

The normal state of *RIntHnd* is waiting for a frame to begin. The variable *inMsg* is set false until a *$A5* character arrives. All other input characters will be discarded. Once a frame has started, each arriving character is checked for escaping. If it is a DLE, the *EscIn* flag is set and the DLE discarded. If a character arrives when the *EscIn* flag is set, the data character is exclusive-ORed with *$40* to get the correct value, and the *EscIn* flag is cleared. *RIntHnd* then updates the input CRC, stores the data character in the input buffer, and updates the pointers (*LAPStash* points at the next free location; *RcvdLen* is the total length of the input buffer).

When a closing framing character arrives, the *inMsg* variable is set false and the frame's received CRC is checked. A nonzero value means that a transmission error occurred, and the data is ignored. A CRC of zero implies that the frame is correct; *RIntHnd* remembers the frame's arrival time and passes control to a higher layer in the AppleTalk protocol for processing.

RIntHnd has several special tests. First, it discards frames that contain either fewer than 3 or more than 600 data characters (as required by the AppleTalk specification). *RIntHnd* also checks for flow control characters arriving from the other side and stops and resumes transmission as necessary. Finally, *RIntHnd* has some tricky code to keep up with arriving data while the processor is busy.

Remember that *RIntHnd* runs as an interrupt routine. No other interrupts will normally be processed until *RIntHnd* exits. Unfortunately, several of the higher protocol layers can take quite a while (3–4 msec) to process a long frame. At 9,600 bps, interrupts are disabled for three or four character times and characters are frequently overrun, corrupting the frame.

To avoid dropping characters while a frame is being processed by a higher layer, *RIntHnd* uses the *stillBusy* flag to indicate that the previous frame is still being processed. When a complete frame arrives, *RIntHnd* sets *stillBusy* and reenables interrupts before passing control to the higher layer's code. Characters that arrive when *stillBusy* is true are placed in a buffer (*BusyBuff*) of 16 characters. Once the higher layer returns, *RIntHnd* clears *stillBusy* and exits.

There is one final complication in these routines—the Macintosh doesn't have enough speed to service the disk and its two serial ports simultaneously. This means that incoming characters may be dropped when the disk is spinning. The disk driver installs a "serial port A polling procedure," or *PollProc*, which is invoked whenever the disk driver turns off interrupts for more than 100 microseconds. During disk operations, *PollProc* stashes characters from port A into a special buffer for processing after the disk stops.

Unfortunately, the Async AppleTalk driver (on port B) drops characters with this scheme. To circumvent this, we install a small piece of code to be executed before the standard *PollProc* runs. This code has one function: to send an XOFF flow control character to stop the other end from sending. A while later, AALAP sends an XON to resume the data (the vertical blanking task controls this).

CRC Algorithm

The two CRC routines shown in Listings Two and Three, next month, implement the same algorithm. Listing Two is in Pascal and is easier to follow than the actual assembly-language code used (in Listing Three). Each *NextCRC* routine receives the accumulated CRC (so far) and the next data character to accumulate. *NextCRC* returns the updated (16-bit) CRC. The CRC-16 algorithm has the special property that when the computed CRC is appended (least significant byte first) to a string of m data bytes, and a CRC computed on the entire m+2 bytes, the result is exactly 0. This makes it quite easy for the receiver of a frame to check the CRC of a frame.

The Polling Procedure (PollProc)

Our *PollProc* gets control when the disk driver turns off interrupts. It first tests to see if first, it has sent an XOFF, and second, if we're receiving a frame. If the answers are no and yes, respectively, it stashes any characters from the SCC in *BusyBuff* and then sends an XOFF to the other end.

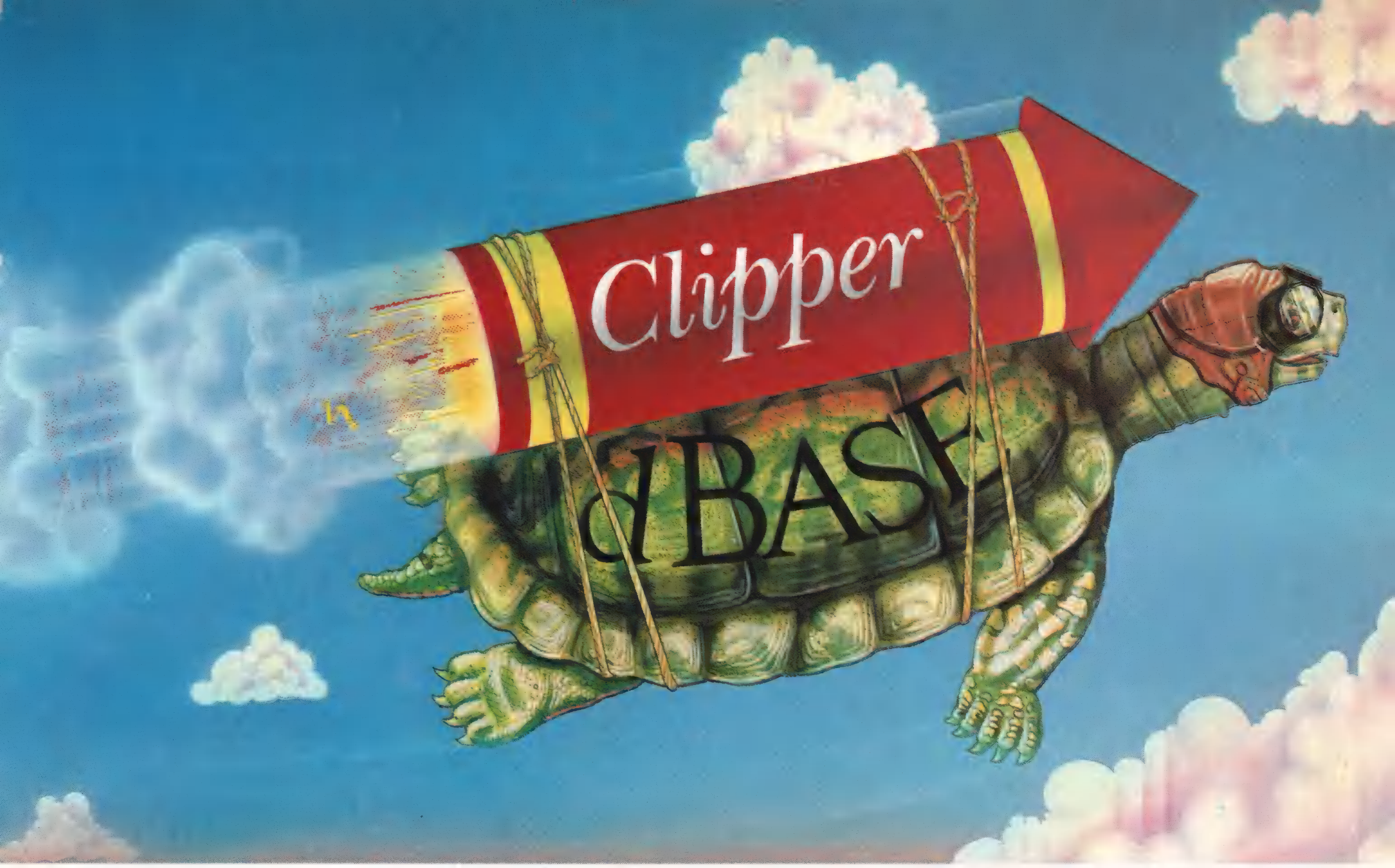
In any case, our *PollProc* then restores the state and passes control to the real *PollProc* (if any).

The AALAP *PollProc* only sends an XOFF when actually receiving a frame (when *inMsg* is true). This prevents a continuous dribble of XOFF and XON characters as the disk spins.

Support Routines

Macintosh programs can receive periodic action with a vertical blanking (VBL) task. Async AppleTalk uses a VBL task to check that the data flow hasn't stopped without reason. The VBL code runs every third of a second and either sends an XON if the transmitter has sent an XOFF to stop the other side or experimentally sends the next character (by calling *TxNextCh*) if no character has been sent for a full second. Each of these actions may reinvoke flow control, but they guarantee that things will become "unstuck" if, say, an XON was dropped.

PutChar sends a character synchronously—that is, it waits until the character can be sent. If the SCC cannot accept the character within one-half second, *PutChar* re-



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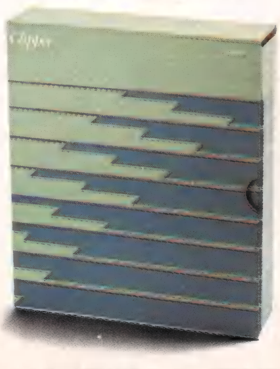

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turns an error code. A character of *$FFFF* will send a break on the link.

SetBaud changes the baud rate generator (BRG) in the SCC to run at the desired speed. It is careful to disable the BRG before changing it and restores the state of the SCC before returning.

Get_NNNN does the network and node number negotiation (NNNN). It sends an IM with the current network address up to four times. A UR response will be processed asynchronously by the receive interrupt handler. If the address in the UR matches that of the IM, then *Get_NNNN* declares the link up. If the *AALAPup* variable is true before the fourth IM time-out, *Get_NNNN* returns a good status; otherwise, it returns a bad status to indicate that the link could not be started.

DoWarn uses the return status from *Get_NNNN* to display a dialog box with a warning to the user that there is trouble with the Async AppleTalk link. Two possibilities are likely: either there is no response from the other end or the two ends of the link cannot agree on a network address. *DoWarn* will fail if the disk that originally contained the Async AppleTalk desk accessory file is not currently mounted.

Who's Using Async AppleTalk?

At Dartmouth, more than 1,000 Macintoshes in administrative and academic offices can use Async AppleTalk through the Kiewit network. We have successfully used many applications, including DarTerminal, printing to LaserWriters, and various file servers and electronic-mail programs, with Async AppleTalk.

At the time of this writing (May 1987), Async AppleTalk is only useful on the Dartmouth network. Fortunately, commercial products that use Async AppleTalk should soon reach the market. First is the Reactor, from Sand Hill Engineering in Geneva, Florida ([305] 349-5960). The Reactor is a port switcher that can interconnect RS-232 ports internally or between several Reactors, which allows multiple users to share a modem, printer, or whatever, without switching cables. The Reactor also acts as an Async AppleTalk bridge, routing AALAP frames between the appropriate ports.

Solana Electronics, of San Diego, California ([619] 566-1701), is also working on an Async AppleTalk product that will connect to a 230.4-kbps bus.

Future Projects

Although the current implementation of Async AppleTalk is quite usable, several enhancements could be made. Perhaps the simplest would be to make an INIT resource that installed Async AppleTalk at system boot time. Each time you booted the system, the INIT mechanism of the Mac would load in the Async AppleTalk driver, dial the telephone (if necessary), and establish the link. Errors would be reported in alerts as they are currently.

Another project is a "half-bridge." This is most easily described as a stand-alone Macintosh that has Async AppleTalk running over the phone port (port A) and standard (230.4-kbps) AppleTalk running on the printer port (port B). Frames that arrived on port A would be sent out port B, and vice versa. This is a bit tricky because not all frames need to be sent out the other port—the software in the half-bridge should forward frames only if the destination is out the other side. This would be useful for a couple of purposes: a half-bridge can join two separate 230.4-kbps AppleTalk networks, only passing frames destined for the other side; a half-bridge also gives a dial-up port for someone using Async AppleTalk, say, from home. (This isn't as wasteful as it seems: it is quite reasonable to leave a Mac in the office running as a half-bridge after people leave. After all, many people turn the Mac off when they're not there.)

Availability

Although you may distribute it freely, Async AppleTalk is not in the public domain. It bears a copyright notice of the Trustees of Dartmouth College. We distribute it at a nominal cost, and others may redistribute it as long as it is not sold for profit and as long as the copyright notice is maintained. The full distribution policy is included with the distribution disk. If you plan to use Async AppleTalk in a commercial product, we ask that you send us a letter describing your plans and your agreement to abide by our policy. (Historical note: this is fundamentally the same arrangement Columbia University uses for its Kermit package.)

Dartmouth College distributes the following modules:

- A desk accessory for the Macintosh.
- Sources for the desk accessory and auto-dialer.
- Sources for most, but not all, of the AALAP driver. AALAP was developed from the original AppleTalk source code, which we licensed from Apple under a nondisclosure agreement. Consequently, we cannot distribute the entire source package. We do show most of the software, including interrupt handlers, so that these can be ported to other machines.

All source code for articles in this issue is available on a single disk. To order, send $14.95 to *Dr. Dobb's Journal*, 501 Galveston Dr., Redwood City, CA 94036, or call (415) 366-3600, ext. 216. Please specify issue number and format (MS-DOS, Macintosh, Kaypro).

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(Listing begins on page 60.)

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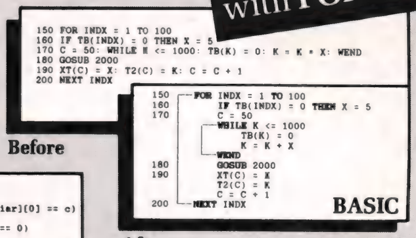

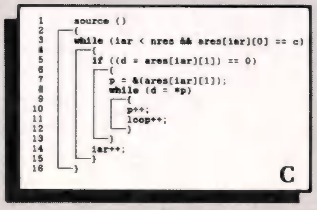

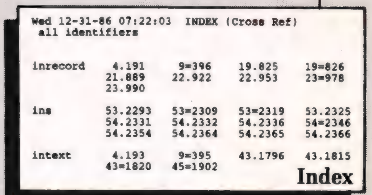

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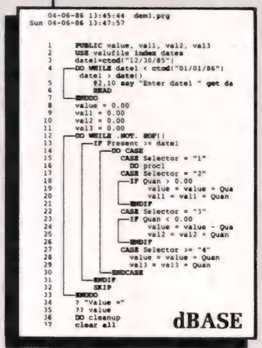

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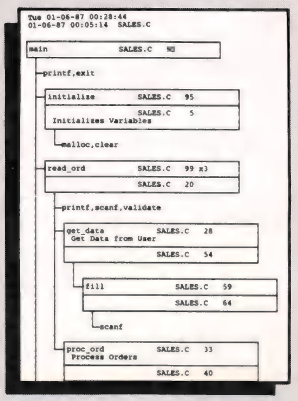

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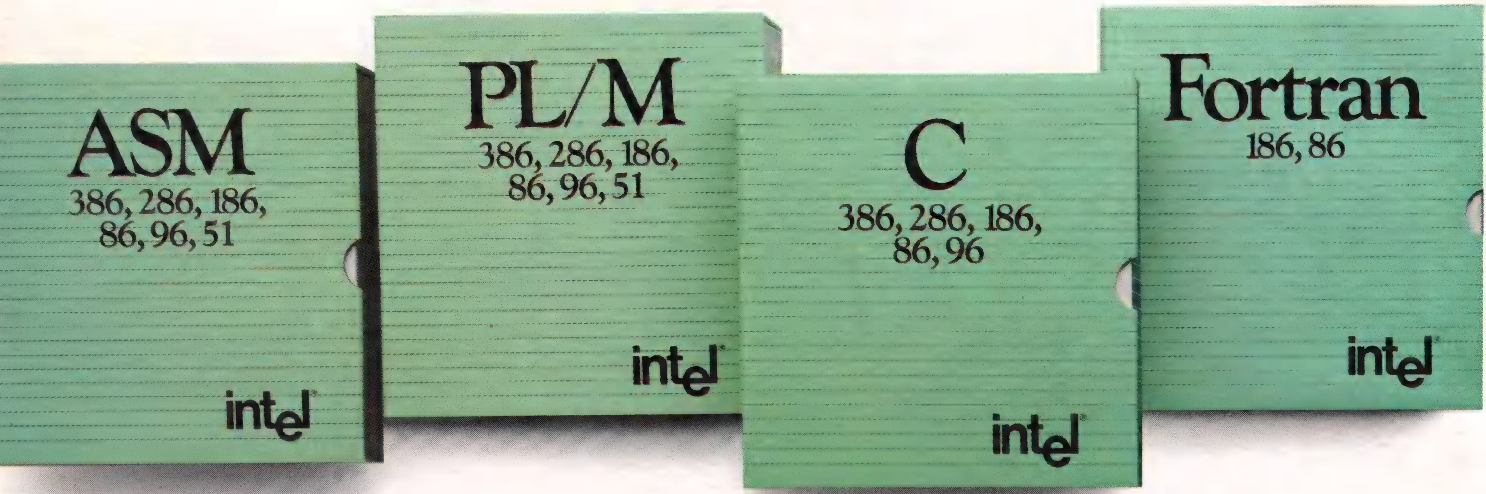

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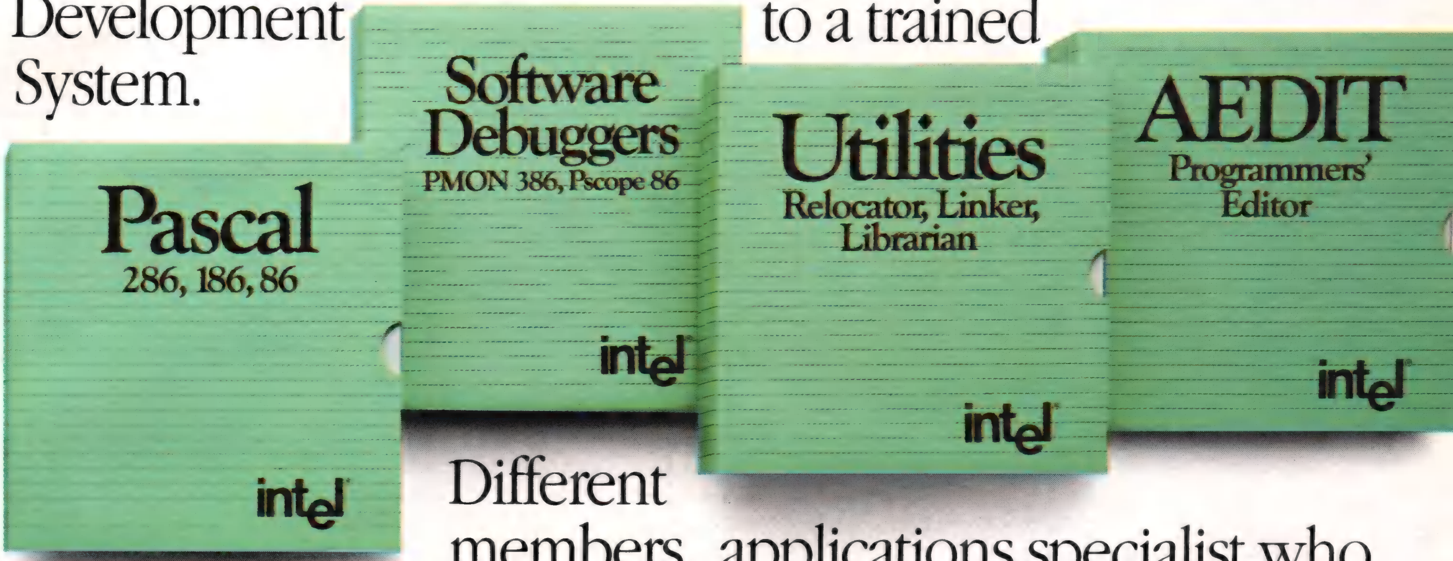

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A Fast Forth for the 68000

Saying good-bye to the inner interpreter

by Lori Chavez

Interactive languages such as Forth and BASIC traditionally force programmers to sacrifice program execution speed for the powerful debugging facilities of an interactive programming environment. This article takes a look at a Forth implementation scheme that allows an interactive Forth system to generate code that executes at speeds that rival the execution speeds of code generated using compiled languages.

Mach2, created for the Macintosh and other 68000 environments, is a Forth system that has discarded the elaborate pointer-threading schemes commonly used for Forth in favor of a simple "subroutine-threaded" approach. In a subroutine-threaded Forth, the Forth compiler generates machine code. Both the pointer-threaded Forth pseudocode and the inner interpreter required to execute the pseudocode are eliminated; the microprocessor can directly execute subroutine-threaded Forth code.

In benchmark tests performed on a Macintosh SE, the Sieve (Forth version) benchmark compiled by Mach2 executed at 70 percent of the execution speed of a Sieve program compiled using a high-performance Macintosh C compiler. The Sieve (Forth version) benchmark compiled using a traditional pointer-threaded Forth system executed at 17 percent of the speed of the compiled C version.

A Short Description of Forth

The Forth language is composed of approximately 200–300 routines. In Forth terminology these routines are referred to as words, or definitions. The data structure used to hold the code for the routines, information about the routines, and to link all the routines is called the dictionary. Each Forth word has its own entry in the dictionary.

New Forth definitions are created by compiling references to several previously compiled Forth words and assigning a name to those compiled references. The new Forth definition, like any other Forth word, can then be executed interactively by the Forth interpreter. Execution of the new definition will cause all words referenced by the definition to be executed sequentially.

To illustrate this process, let's define a Forth word called *SHIP* that, when executed, will perform the steps required to ship a product from a warehouse:

```
: SHIP
GET_QUANTITY
PREPARE_SHIPMENT
SEND_PACKAGE
;
```

GET_QUANTITY fetches the desired quantity value from a variable and passes the value to *PREPARE_SHIPMENT*. *PREPARE_SHIPMENT* places the desired number of items in the package and *SEND_PACKAGE* puts the package in the mail.

Subroutine vs. Pointer Threading

Figure 1, page 33, shows the code generated when *SHIP* is compiled in a subroutine-threaded system. Each word that *SHIP* references is a subroutine that ends in an assembly-language return-to-subroutine (RTS) instruction. The compiler generates a 4-byte, PC-relative, jump-to-subroutine (JSR) reference for each of the three routines. Because *SHIP* itself ends with an RTS instruction, it too can be referenced by another word in the same manner.

Figure 2, page 33, shows how the dictionary entry for *SHIP* would appear if it were compiled in a pointer-threaded Forth implementation. A pointer-threaded Forth does not generate directly executable machine code. Instead, it generates lists of either addresses, offsets, or tokens that indirectly "point" to the referenced word. This means a Forth interpreter that understands this "pseudocode" generated by the pointer-threaded compiler must be used to execute the "code."

Why Pseudocode?

Forth was originally developed in the days of the 8- and 16-bit processors. Typically, only one of the registers in these processors—the system stack pointer register—could take advantage of the fast processor stack manipulation operators (push and pop).

In a pointer-threaded Forth, the processor system stack is used as the data stack. Because microprocessors use the system stack for their subroutine calling mechanism, pointer-

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threaded Forth implementations were forced to develop their own definition execution mechanism. The scheme devised involved a simulation of the microprocessor program counter, instruction pointer, and even the instruction set. For those interested, Ronald Greene provides a listing of the 8088 assembly-language code required to implement a generic inner interpreter in his 1984 *Byte* article on reducing overhead in threaded interpretive languages. The inner interpreter is naturally slower than the microprocessor's subroutine calling mechanism and requires more registers to implement.

It is this simulation of the natural functions of the microprocessor that became the bottleneck in the effort to achieve fast Forth execution times. At the time, given the architecture of the available processors, the Forth implementors' decision made sense. The data stack is heavily used in a Forth program. By using the system stack as the data stack, fast push and pop stack manipulation instructions could be used to optimize parameter passing. And, in those days of limited memory, the use of subroutine call instructions would have required more memory for each compiled reference in a Forth word.

Today, however, processors are much more flexible. The Motorola 68000 microprocessor has 16 general-purpose registers (*D0–D7* and *A0–A7*), 7 of which (*A0–A7*) can be used as stack pointer registers. This means that a 68000 Forth can take advantage of the 68000's subroutine calling mechanism, which affects the system stack pointer register, and still use another register for the parameter stack pointer with no speed penalty.

Optimization Techniques

As Figure 1 demonstrated, a subroutine-threaded Forth compiler generates machine code. Although this may seem only natural to those familiar with other language compilers and assemblers, it is not a common characteristic of Forth. This change from pseudocode to machine-code generation has had two positive effects on the Forth language. First, as the previously mentioned Sieve results testify, subroutine threading makes Forth code execute significantly faster. Second, the code and speed optimization techniques traditional compilers and assemblers have used for many years can finally be applied to Forth code.

The rest of this article discusses how macro substitution—a speed improvement technique commonly used by assemblers—and edge-macro (peephole) optimization—a code optimization technique commonly used by traditional language compilers—can be used by a subroutine-threaded Forth compiler to generate faster and more compact code.

Optimization for Speed

To obtain speed improvements in an assembly-language program, programmers generally avoid subroutine calls and place as much code as possible directly into the routine being optimized. If this technique is used too often in a program, the source listing can become quite long and unreadable. Therefore, most assemblers include some sort of macro facility that allows many instructions to be represented by one word. When the macro word is encountered during the assembly process, all instructions that comprise the macro word will be assembled.

"Mach" words are the Mach2 equivalent of a traditional assembler's macro words. In Mach2, one bit in the length byte of the dictionary header is used as the Mach bit. If this bit is set, the corresponding word is a Mach word that is treated as a macro by the compiler. Whenever a Mach word is referenced in a definition, the compiler lays a copy of all instructions from the start of the Mach word up to the first RTS encountered into the definition being compiled. Because the compiler in a subroutine-threaded Forth already generates machine code, teaching it to produce in-line code is a simple task.

To decide which Forth words should be laid in-line, the overhead of the subroutine call instruction must be weighed against the size of the subroutine being called. The 68000 PC-relative JSR instruction requires 4 bytes of memory and 18 processor clock cycles. The 68000 RTS instruction requires 2 bytes of memory and 16 processor clock cycles. The total overhead for a complete subroutine call, for both the JSR and RTS instructions, is therefore 6 bytes and 34 clock cycles. For approximately 75 percent of the words in the Forth kernel, the overhead of the subroutine calling mechanism is small in comparison to the size and time required to execute the word itself. For the remaining 25 percent of the words, however, the overhead involved in calling the words is much greater than the execution time and memory requirements of the word being called.

An ideal candidate for a Mach word is a word such as *DUP*, which is composed of a single 68000 instruction (*MOVE.L (A6),–(A6)*) that is both smaller in size than the JSR instruction (2 bytes vs. 4 bytes) and faster in

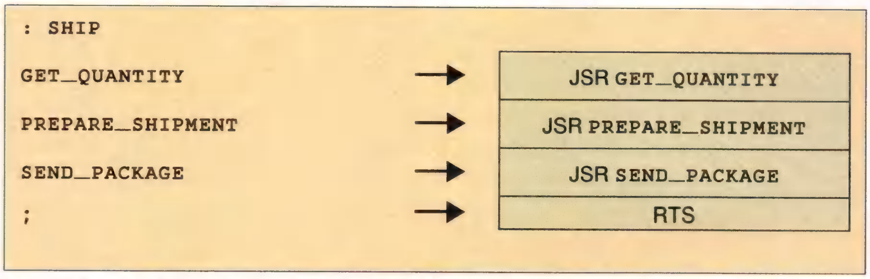

Figure 1: *Subroutine-threaded code for* SHIP

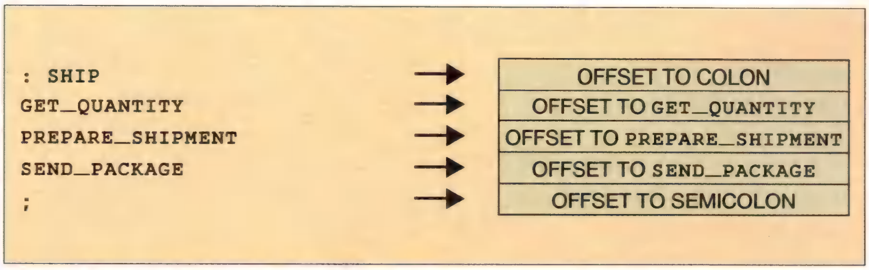

Figure 2: *Pointer-threaded code for* SHIP

68000 FORTH
(continued from page 33)

execution time than a subroutine reference (20 processor cycles for *DUP* vs. 54 processor cycles for *JSR + DUP + RTS*).

In Mach2, all of the simple stack, arithmetic, comparison, and memory operators and all variable and constant references have been declared as Mach words. Fifty percent of these words generate code that is smaller than or equal in size to the JSR instruction they replace. An additional 25 percent of the words weigh in at 6 bytes—only 2 bytes larger than the JSR instruction. In each case, the replacement of the JSR instruction with in-line code results in at least a 50 percent speed improvement. When used thoughtfully and selectively, macro substition can yield a large increase in program execution speed with only a small increase in program size.

One example, the definition of *GET_QUANTITY*, is shown below. *QUANTITY* is the name of a 4-byte variable storage area. When executed it will return the address of its storage area. The @ operator (fetch) is used to fetch the 4-byte contents of the *QUANTITY* variable.

```
: GET_QUANTITY   ( – n ) \ n means
     a value is returned on the stack.
  QUANTITY  \  Return variable
               address
  @ ;          \ Fetch 4-byte value
               from variable
```

Both the variable reference and @ are Mach words. By placing *QUANTITY* and @ directly into *SHIP*, you can eliminate the overhead of the *GET_QUANTITY* subroutine call and experience the benefits of macro substitution.

Figure 3, below, shows the code generated for *SHIP* when the code for the *QUANTITY* variable reference and the @ memory access are treated as assembly-language macros and laid in-line into *SHIP*'s code area. As you study Figure 3 note that Mach2 variables are located relative to the address in the *A5* register and that the *A6* register is used to maintain its parameter stack.

With macro substitution, the 4-byte JSR *QUANTITY* is replaced with the 4 bytes of assembly-language code that perform the variable reference. Likewise, the 4-byte JSR @ is replaced with the 4 bytes of assembly-language code that perform the memory access. *SHIP* doesn't increase in size but the *QUANTITY @* part of *SHIP* experiences a 57 percent speed improvement.

Code Optimization

Because Forth words use a stack for parameter passing, it is common for the first instruction in a Forth word to pull a parameter from the stack (*MOVE.L (A6)+,A0*) and for the last instruction to put a parameter on the stack (*MOVE.L A0,–(A6)*). When two Forth Mach words that have these common beginning and ending instructions are butted together, as in Figure 3, the result is the following redundant and inefficient code sequence:

```
. . .
MOVE.L A0,–(A6)
MOVE.L (A6)+,A0
. . .
```

Fortunately, it is not hard for the compiler to watch for these edge macro conditions and eliminate unnecessary code if possible (see Figure 4, below). With the use of this edge macro optimization, the *SHIP* code becomes faster and more compact. Two instructions, 4 bytes, can be removed from the *QUANTITY @* code and the required clock cycles then drop from 52 cycles to 28 cycles.

Conclusions

The advantages of subroutine threading are many—for example:

1. Speed—By removing the inner interpreter and using code and speed optimization techniques, subroutine-threaded Forth code executes three to four times faster than pointer-threaded Forth code.
2. Sharable code—Linking to other languages is simpler. Because all languages involved use only machine

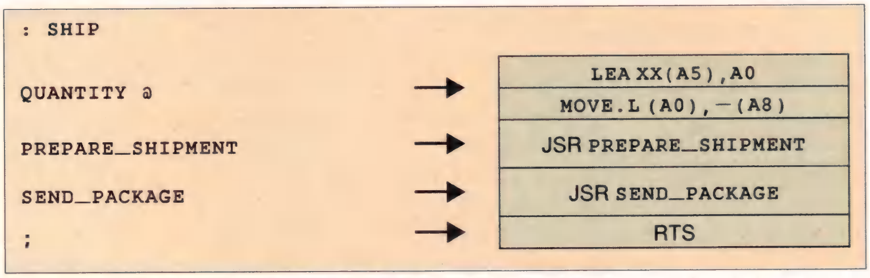

Figure 4: *Subroutine-threaded code for* SHIP *(with macro substitution and edge macro optimization)*

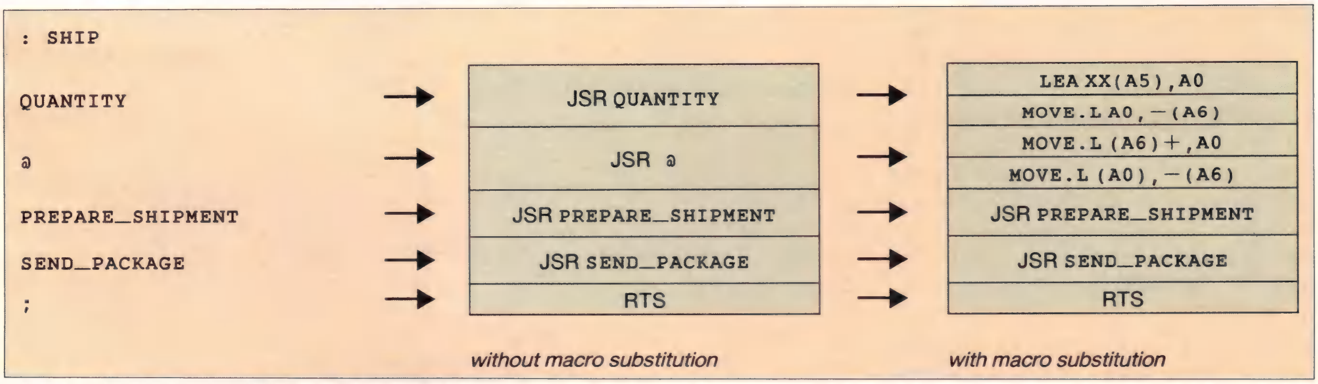

Figure 3: *Subroutine-threaded code for* SHIP

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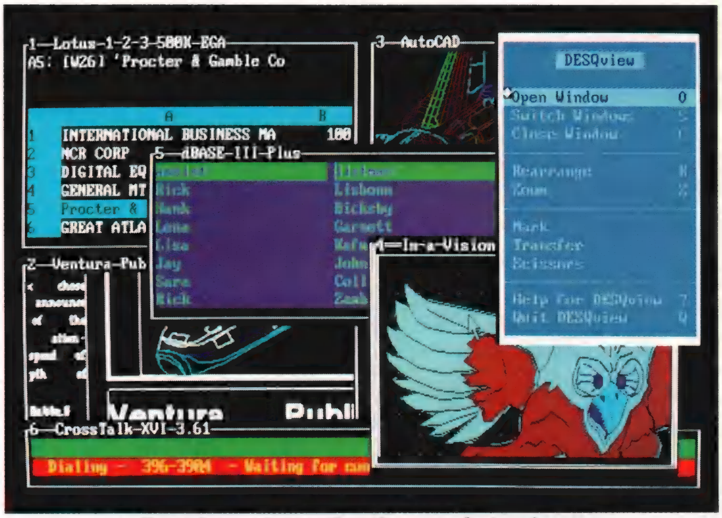

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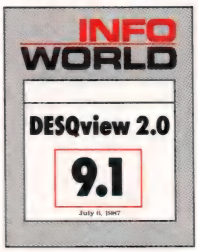

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68000 FORTH
(continued from page 34)

code instructions, only register saving and setup are required.

3. Conventional—The implementation is easy for non-Forth programmers to understand and use.
4. Relocatable code—The use of PC-relative subroutine references means the code generated is relocatable.
5. Well-suited to systems-level programming—It is easy for a subroutine-threaded compiler to generate stand-alone assembly-language routines, such as those required for device drivers.

Subroutine threading has disadvantages in the areas of size of generated code and the ease of disassembly.

Regarding size, with the inclusion of a subroutine call instruction with each reference and the use of macro substitution, the code generated by a subroutine-threaded Forth will be 50–100 percent larger than code generated by a pointer-threaded Forth.

The ease of disassembly is, happily, not a problem every software developer will face. Subroutine-threaded code is easier to disassemble than pointer-threaded code. Therefore it is correspondingly harder to disguise proprietary algorithms written in a subroutine-threaded Forth.

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Greene, Ronald. "Faster Forth: Reducing Overhead in Threaded Interpretive Languages." *Byte* (June 1984): 127.

Loeliger, R. G. *Threaded Interpretive Languages.* Peterborough, N.H.: Byte Books, 1981.

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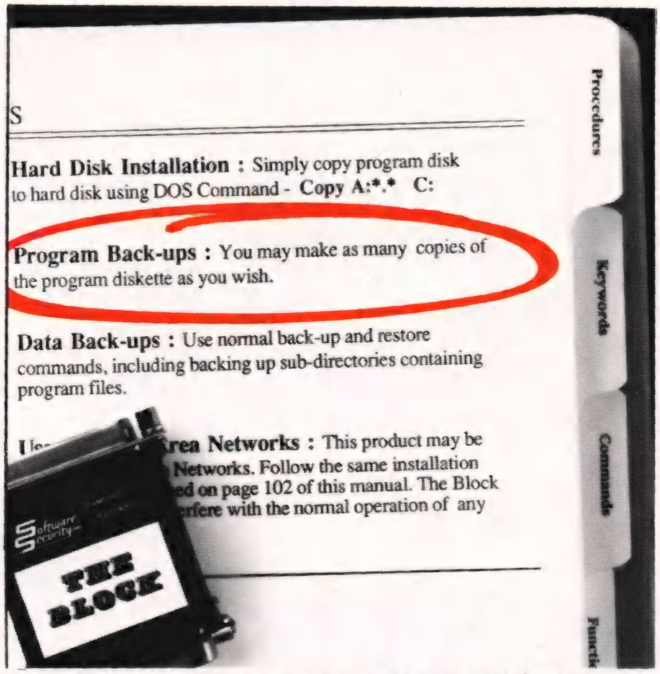

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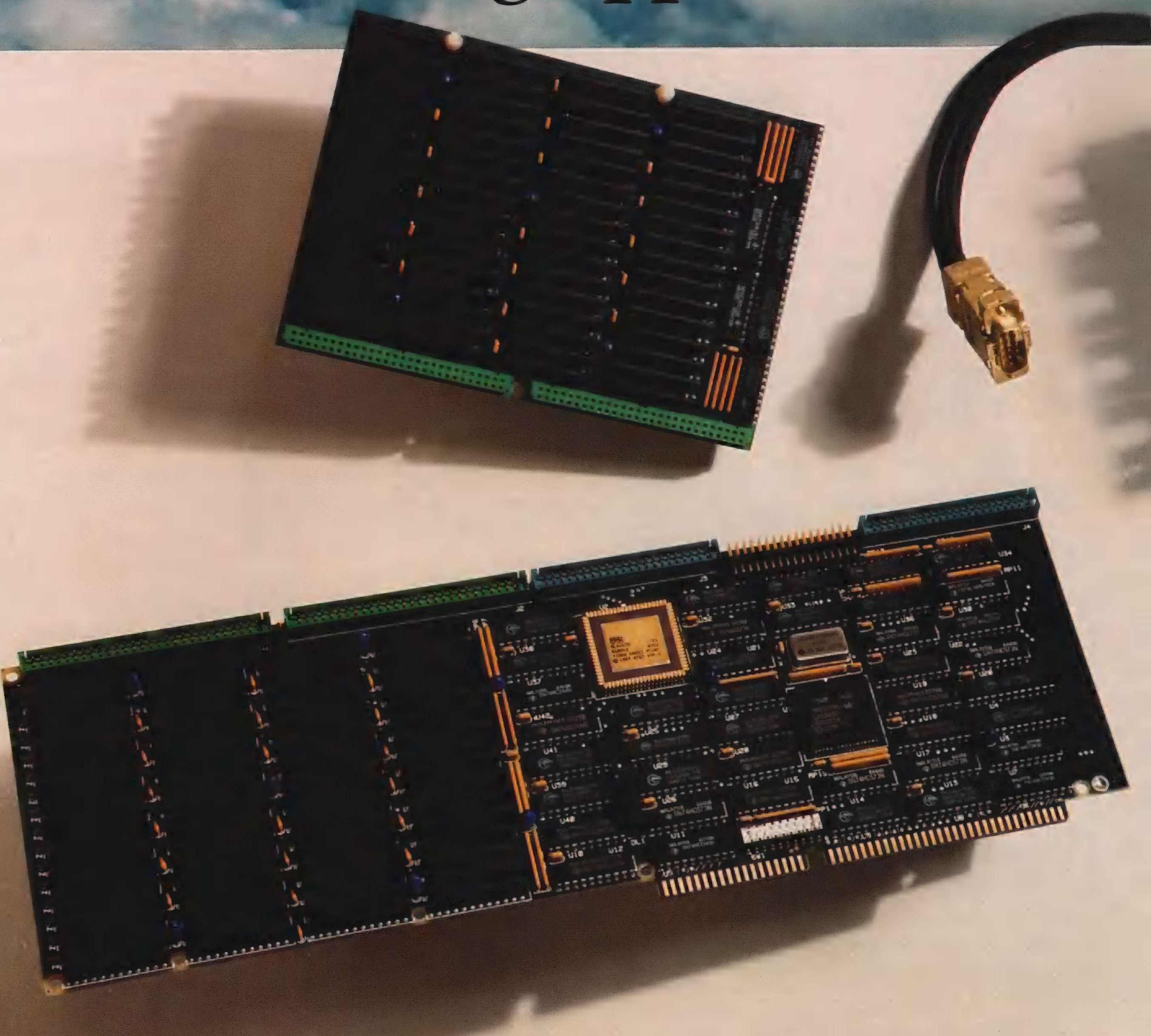

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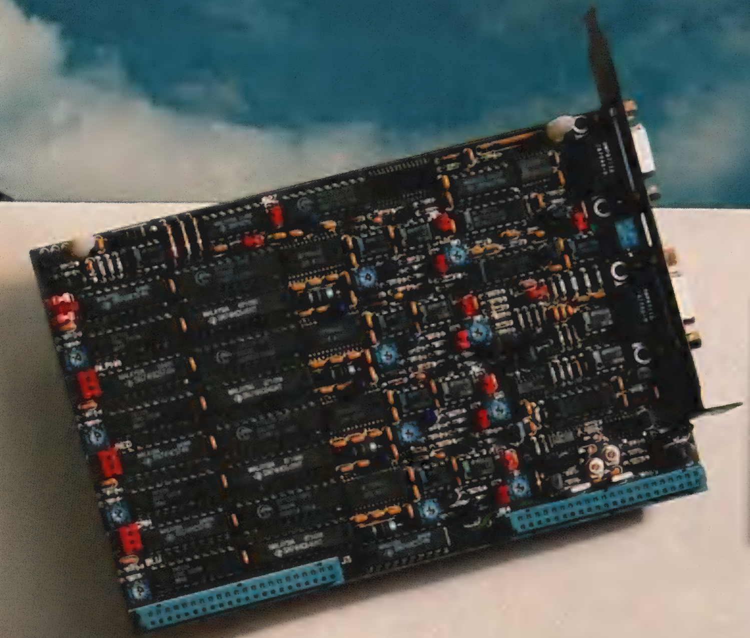

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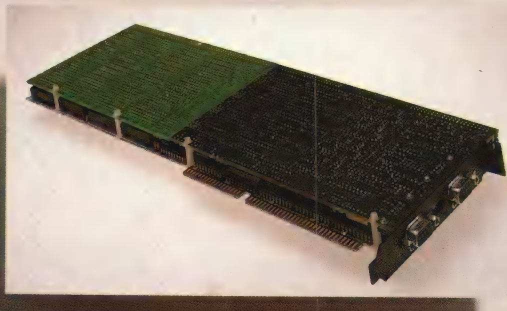

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CAPTURE RESOLUTIONS:*

NTSC	PAL
(RS-170A)	(CCIR-624)
756x486	738x576
604x486	590x576
504x486	492x576
432x486	422x576

Resolutions are programmable; these are nominal ones for interlaced NTSC and PAL compatible.

DISPLAY RESOLUTIONS:*

NTSC	PAL	Interlaced	Non-Interlaced
(RS-170A)	(CCIR-624)		
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1008x486	984x576	(60 Hz)	(50 Hz)
756x486	738x576		
604x486	590x576	768x768	756x486
504x486	492x576	(80 Hz)	(60 Hz)

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A Forth Standard Prelude

by Martin Tracy

Can the Forth-83 Standard dialect be used to write substantial programs? The answer is a qualified "yes." The qualification is that the program must be preceded by a software "prelude." The purpose of this prelude is to provide the program with those facilities that cannot be found within the Standard. The good news is that the prelude can be surprisingly short.

Two years ago, I began editing programs for the Forth Model Library, which is sold by the Forth Interest Group (FIG). The programs had been submitted by different authors and were written in various implementations of the Forth-83 Standard dialect. Each program consisted of 70 to 120 screens of source code. My task was to convert these programs to forms that would run equally well under several available Forth-83 implementations.

I found that a program written in one Forth-83 implementation would not run correctly under another. The reason for this was simple. The authors needed software tools that could not be provided by the Standard but that were instead provided by the implementation. The solution to the problem was also simple. I wrote a software prelude, one for each implementation, that provided the missing functions. The user of a particular Forth-83 package then simply loaded these screens before loading the program.

When I say "could not be provided by the Standard," I do not mean words that do not happen to appear in the Standard but that can be written using Standard words. Take, for example, the words *NIP* and *TUCK*, which can be found in the Laxen/Perry F83 implementation:

```
: NIP ( n n2 — n2)       SWAP DROP ;
: TUCK ( n n2 — n2 n n2) SWAP
                               OVER ;
```

Forth recurses faster and more naturally than any other popular language.

As you can see, these words can be defined using the Forth-83 Standard words *SWAP DROP* and *OVER*. Thus, although *NIP* and *TUCK* are not mentioned in the Standard, they can be written with Standard words and used in Standard programs. It is up to the author (or the hapless editor) to make sure these words are defined before use.

Recursion

Consider, on the other hand, recursive definitions. The Forth-83 Standard does not mention recursion in its Required Word Set, although it defines *RECURSE* in the Controlled Reference Word Set:

```
RECURSE  --       C,I,83
         -- (compiling)
```

"Compile the compilation address of the definition being compiled to cause the definition to later be executed recursively."

Controlled reference words are word definitions that "although not required, cannot be present with a non-standard definition in the vocabulary FORTH of a Standard System."

You would know what *RECURSE* meant if you saw it in a Standard program. This does not mean, however, that programs using recursion must do so with *RECURSE*. Some implementations prefer the word *MYSELF*. Others, like Laxen/Perry F83, provide a different mechanism entirely: words whose definitions begin with the command *RECURSIVE* can refer to themselves.

In other words, the Standard says "a word by this name has this function and syntax" rather than "this function is performed by a word of this name and syntax." The confusion of form and function is apparent in other places as well. Consider the definition of *>NAME* in the "Experimental Proposal: Definition Field Address Conversion Operators":

>NAME addr1 – addr2 "to-name"
"addr2 is the name field address corresponding to the compilation address addr1."

The form or syntax of this word is the same as its function: to take you from the compilation address to the name field address. Because you don't know the structure of the name field, however, you can't do anything with it. The underlying function you really want is to display the name of a word, given its compilation address.

Is recursion important? You bet. Forth recurses faster and more naturally than any other popular high-level programming language, including C and LISP. Why? First of all, because

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Forth words keep the majority of their arguments on the stack, which is a naturally recursive structure. Second, because Forth generally does not use local variables and so has no stack frame or other lexical structure to build each time it recurses.

A popular belief, even among Forth programmers, is that recursion should be avoided because the return stack is small. The Standard guarantees a return stack of only 48 bytes. But this only means that "tail-recursive" problems, such as those that visit each item on a list, should be unravelled into iterative structures, such as a *DO* loop. (Modern LISP compilers do this automatically.) There is an equally rich set of "head-recursive" problems, however, that recurse only to the depth of the problem and not to its breadth. These are problems such as shape-filling algorithms, tree traversal, and natural language parsing, which seldom recurse any deeper than eight or nine levels.

Fortunately, *RECURSE* can be defined easily even in implementations that do not include it. For example:

```
: RECURSE   [COMPILE] MYSELF ;
                        IMMEDIATE
```

This definition is likely to be a "one-liner" even in implementations that support some other recursion mechanism entirely. Why? Because the concept of recursion is simple and natural to the Forth language. Simplicity and harmony are the guidelines for selecting words for the Standard prelude.

Compiler Words

The Forth-83 Standard provides a set of words to support the compiler, such as *[COMPILE]* and *IMMEDIATE.* These words can also be used to extend the compiler. They are, in fact, the building blocks for new compiler words. Compiler words are used in Forth to build flow-of-control structures and to "hide and provide" in-line data in colon definitions. The extensible compiler is one of the true strengths of the Forth language.

Compiler words generally have two functions: they must compile both a run-time operator and the in-line data upon which it operates. The run-time operator also has two functions: it must operate meaningfully on the in-line data, and it must adjust the Forth instruction pointer (which I will call *I*) to skip over this data.

Unfortunately, the Standard does not provide for the creation of new run-time words. A run-time word has no Standard way of finding or skipping over the following in-line data. Consider how the word *LITERAL* might be defined:

```
: lit ( — n) R> DUP @ SWAP 2+ >R ;
: LITERAL   COMPILE lit , ;
                        IMMEDIATE
```

LITERAL compiles the run-time word *lit*, followed by the number on the stack. Because *lit* is a colon definition, you might expect *R>* to move *lit*'s return address to the data stack. Furthermore, the return address of *lit* should be the address of the in-line data that follows, right? Actually, this definition of *lit* will work correctly on a great many Forth implementations. Not all Forths increment the instruction pointer *I* to point to the next address, though. Some increment it only on demand, reasoning that the increment is wasted when it precedes a branch. Others compromise and only increment it to point to the next byte. In these cases, *R>* points near to but not directly at the in-line data and must be adjusted. The adjustment can be hidden in the way shown in Example 1, below. Experience has shown that this solves the problem in almost all cases. *I>* (*I*-from) and *>I* (to-*I*) have even been written for a Forth with a 16-bit data stack width and a 32-bit return stack width and have worked correctly.

Alignment

Now consider an often requested function—the in-line string compiler. Usually called simply *"* (double quote), it might be implemented in this way:

```
: (") ( — addr n)   I> @ COUNT 2DUP
                              + >I ;
: "    COMPILE (") 34 WORD
              DUP C@ ( n ) 1+ >R
       COUNT HERE SWAP CMOVE R>
              ALLOT ; IMMEDIATE
: EXAMPLE
   " EXAMPLE prints a string." TYPE ;
```

This definition of *"* works, in principle, on strings with an odd number of characters. Otherwise, on a byte-addressed machine with even address or "cell" alignment, the definition fails. On some Motorola 68000 Forth implementations, the failure is fatal.

You can easily define a pair of words to hide address alignment, provided you are able to make one simplifying assumption: Forths that

```
: I> COMPILE R> ; IMMEDIATE ( no offset)
: >I COMPILE >R ; IMMEDIATE ( no offset)

: I> R> R> 1+ SWAP >R ; IMMEDIATE ( one-byte offset)
: >I R> SWAP 1- >R >R ; IMMEDIATE ( one-byte offset)

: I> R> R> 2+ SWAP >R ; IMMEDIATE ( two-byte offset)
: >I R> SWAP 2- >R >R ; IMMEDIATE ( two-byte offset)

: lit ( — n) I> DUP @ SWAP 2+ >I ;

: LITERAL COMPILE lit , ; IMMEDIATE
```

Example 1: *A way to hide the adjustment of* R>

```
: ALIGN ; IMMEDIATE ( no alignment)
: REALIGN ;    ( no alignment)

: ALIGN HERE 1 AND ALLOT ; IMMEDIATE ( cell-alignment)
: REALIGN ( a — a') DUP 1 AND + ; ( cell-alignment)

: (") ( — addr n) I> @ COUNT 2DUP + REALIGN >I ;

: " COMPILE (") 34 WORD DUP C@ ( n ) 1+ >R
  COUNT HERE SWAP CMOVE R> ALLOT ALIGN ; IMMEDIATE
```

Example 2: *A definition of " when the dictionary is aligned*

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FORTH PRELUDE

(continued from page 41)

use cell alignment keep the dictionary in an aligned state at all times. Even if the dictionary is only aligned while compiling a definition, you can define *"* with *ALIGN* and *REALIGN* as shown in Example 2, page 41.

You might argue that the word *"* should be in the Standard prelude instead of the *ALIGN* and *REALIGN* pair. The trouble with *"* is that it's not simple enough. It leaves you with no way to compile a sequence of nonprintable control characters or to align a *CREATE . . . DOES>* structure. Furthermore, there is no general agreement among implementors as to whether *"* should return the one-argument address of a counted string or the two-argument address of the first character and its length—a form suitable for *TYPE*. By redefining *"* in the Standard prelude, you can guarantee its syntax.

Interpreting a String

The Forth-83 Standard describes the terminal input buffer in such a way that you might think that if you *CMOVE* a string into *TIB*, store its length into *#TIB*, and set *BLK* and *>IN* to 0, then you will force the Forth text interpreter to interpret the string. Why would you want to do that? Well, it is handy to be able to compile a word such as *FIND* or *FORGET* in a colon definition along with its argument.

Unfortunately, these words are defined to read their arguments from the input stream. How nice if you could compile the input stream as well:

```
: ME ( Initialize system, then. . .)
                    " FORGET ME" EVAL ;
```

I am assuming that *EVAL* does the work of moving the string into *TIB* and so on. In the same manner, you could use *FIND* to see if a particular word is present in the dictionary:

```
: WELL?   " FIND ME" EVAL IF . . .
```

You could also create words from within other words and reference words before they are defined. The fundamental right to treat (string) data as an executable program is guaranteed by the Von Neumann architecture.

I have borrowed the word *EVAL* from the LISP function by the same name. The problem with *EVAL* is that it's not simple enough. The Standard already lets you set up *TIB #TIB >IN* and *BLK*. But it provides you with no way to invoke the text interpreter to interpret it. The function you are missing is *INTERPRET*. Like *RECURSE*, it is found in the Controlled Reference Word Set:

INTERPRET -- M,83
"Begin text interpretation at the character indexed by the contents of >IN relative to the block number contained in BLK, continuing until the input stream is exhausted. If BLK contains zero, interpret characters from the text input buffer."

Given *INTERPRET*, you can now define a simple *EVAL*:

```
: EVAL ( a n)   DUP >R TIB SWAP
                   CMOVE R@ #TIB !
  0 >IN ! 0 BLK ! INTERPRET R> >IN
                                 ! ;
```

The sequence *R> >IN !* marks the input stream as exhausted. I have chosen the two-argument string form. With *INTERPRET*, you can implement either string form.

Screen Display

The six words *RECURSE*, *INTERPRET*, *I>*, *>I*, *ALIGN*, and *REALIGN* supply the most often requested non-Standard functions. The most often requested extension, however, is for video screen control. Virtually all available Forth-83 implementations allow the programmer to control the appearance and cursor position of the video display. A smart presentation can mean more to a program than a string stack or floating-point math.

Although video displays vary widely, modern displays have been standardized to a gratifying extent. You can, in fact, add a fairly good screen display extension to the Standard prelude if you follow a few simplifying assumptions and rules:

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2. Define the word *PAGE* to clear the entire screen and home the cursor to

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FORTH PRELUDE
(continued from page 43)

the upper left-hand corner.

3. Define the word *TAB (x y)* to position the cursor at the given *x* (character) and *y* (line) coordinates. Coordinate pair (0,0) is in the upper left-hand corner.
4. Define the word *MARK (a n)* to print the given two-argument character string in highlight or inverse video.
5. Never write into or over column 79. Never issue a carriage return from row 23. In other words, you do not face the issues of wrapping the line or scrolling the display.

It turns out that these five restrictions are sufficient to generate some really nice displays.

Cell Addressing

The Forth-83 Standard describes only implementations on byte-addressed CPUs with a 64K address space. Future Forth standards are likely to consider much larger address spaces. There are already several 32-bit Forth implementations.

A Standard Forth implementation assumes that there are 2 bytes per cell, and Standard programs are filled with 2+s and 2*s accordingly. On a byte-addressed 32-bit Motorola 68000 implementation, however, there are 4 bytes per cell. On a cell-addressed Novix 4016 or Texas Instruments TMS32020, there may be only 1 byte per cell. The number of bytes per cell is used mostly to specify how much dictionary memory to allocate or how to skip to the next cell of a data structure.

It can be hidden from an application with *CELL*, *CELLS*, and *CELL+* as shown in Example 3, page 45.

Byte order within a cell is normally not a problem. Bytes that are written by byte operators should be read by byte operators. Be careful when you define byte operators that are based on cell operators to make them independent of the byte order.

An Experimental Proposal

The Forth community has long been searching for a solution to a classic programming problem: the string search. When you search for characters in a string, you generally use a

DO loop. You leave the loop in one of two circumstances:

1. The search is successful. You leave the loop immediately.
2. The search is unsuccessful. You leave the loop because it is exhausted.

The problem is that once you have left the loop, how do you know if the search was successful?

One solution is to maintain a flag on the stack:

```
: SEARCH . . . 0 ( flag ) ROT ROT
  DO DROP . . . ( compare strings ) =
    IF . . . -1 LEAVE THEN 0 ( flag )
  LOOP ;
```

If the search is successful, the flag will be true.

Leo Brodie, Wil Baden, and others point out that a much better approach is to leave the loop and the word that contains it when the search is successful:

```
: SEARCH . . .
  DO . . . ( compare strings ) =
    IF . . . -1 LEAP ( leave word entirely) THEN
  LOOP 0 ;
```

LEAP is Leo Brodie's suggestion, but it has the usual problem: it's not simple enough.

Wil Baden's solution looks like this:

```
: SEARCH . . .
  DO . . . ( compare strings ) =
    IF . . . -1 UNDO EXIT ( leave word entirely) THEN
  LOOP 0 ;
```

The command *UNDO* "undoes" the loop by discarding the index, limit, and any other loop items on the return stack before leaving the word with *EXIT*. *UNDO* has the additional charm that it can leave a word from a nested loop, as in *UNDO UNDO EXIT*.

UNDO could be defined as a colon definition in this way:

```
: UNDO I> R> R> 2DROP >I ; (discard 2 items)
: UNDO I> R> R> 2DROP R> DROP >I ; ( discard 3 items)
```

Actually, *UNDO* is more easily defined as a *CODE* definition and in some implementations is only one instruction.

In Summary

The Forth Standard prelude described in this article (see Listing One, page 90) has proven to be an effective way to write substantial programs that run unchanged on several different implementations of the Forth-83 Standard. The prelude can hide differences in byte addressing and cell alignment from the application programmer. As more experience is gained, it may be possible to extend the prelude to hide ROM-ability and other implementation dependencies.

```
2 CONSTANT CELL ( byte-addressed 16-bit cells)
: CELLS 2* ; ( size of cell area in bytes)
: CELL+ 2+ ; ( skip to the next cell address)

4 CONSTANT CELL ( byte-addressed 32-bit cells)
: CELLS 4 * ; ( size of cell area in bytes)
: CELL+ 4 + ; ( skip to the next cell address)

1 CONSTANT CELL ( cell-addressed one-byte-per-cell)
: CELLS ; ( size of cell area in bytes)
: CELL+ 1+ ; ( skip to the next cell address)

CELL ALLOT ( allocate a cell)
10 CELLS ALLOT ( allocate 10 cells)

( addr ) DO . . . CELL+ ( skip to next cell) LOOP
```

Example 3: *A way to hide the number of bytes per cell*

Availability

All the source code for articles in this issue is available on a single disk. To order, send $14.95 to *Dr. Dobb's Journal*, 501 Galveston Dr., Redwood City, CA 94063, or call (415)366-3600.

Bibliography

Baden, Wil. "Escaping Forth." *1986 FORML Proceedings*. Available from the Forth Interest Group ([408] 277-0668).

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(Listing begins on page 90.)

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Pattern Matching Using Finite State Machines

by Charles F. Bowman

If you're a programmer, the chances are you've had to deal with the problem of pattern matching. It can be a simple problem solved with a trivial string comparison utility, or it can be so complex as to require the use of a lexical analyzer.

Most people deal with pattern matching every day: as part of a search-and-replace operation in a text editor, as a means of data retrieval in a database application, as unique identifiers in program source code, and so on. Because the task is so common, it's worthwhile to examine ways to perform it as efficiently as possible. This article describes how state machines can be useful in solving this type of problem.

To demonstrate the use and effectiveness of state machines, this article provides the source code for a program called findcmd. The program does just what the name implies—it finds commands. When invoked, the program searches each component of the user's *path* variable for all programs (files) that match the supplied pattern arguments. The pattern string can contain wildcard characters just like those the DOS command shell accepts. The program uses an extension of the Knuth-Morris-Pratt (KMP) algorithm, which implements pattern matching using a finite state machine—more on this later.

State Machines

A complete and formal discussion of Turing machines, automata theory, and so on is beyond the scope of this article. For a more detailed discussion of the topic, see the bibliography.

The program searches each component of the path variable for all files that match the pattern.

In general, a state machine has the following attributes:

- A finite set of states, including an initial, or start, state and a stopping, or end, state.
- A finite set of state transitions (a collection of moves the machine can make). Generally, the transitions are represented as a two-dimensional array, indexed on one axis by the current state number and on the other axis by the current input token.
- A set of input symbols (alphabetical) on which the state transitions will occur (for my purposes, I define this as the file names that will be compared with the pattern arguments).
- A read head that points to the next available input character.

The basic operation of a state machine can be described as follows. Upon invocation, the machine is initialized to the begin state. It then iteratively examines the current input symbol and, using the set of state transitions, progresses or moves to the next state, advancing the read head as required. It continues this process until it encounters either an error condition or an accepting state. The actual transition decisions are accomplished by what is effectively a table lookup. Both the current state and current input token are used to index into the transition table to determine the resulting action of the machine. The range of actions includes stop (error), accept, and move (to new state).

The stop action occurs when the current input token is invalid with respect to the current state. This situation raises an error condition that usually results in the machine halting (in a compiler, for example, this would typically be the point at which you would receive a message such as "syntax error line 16"). The accept action occurs only when the machine is in a valid halt state and has exhausted the input stream (the read head points to the end of a file). (In a compiler, this would mean your source code was syntactically correct.) The intermediate transition states comprise the remainder of the table; they move the machine from state to state based on the input stream.

There are two important points to note here. One is that the machine is not required to absorb an input symbol (advance the read head) with each state transition. It is perfectly acceptable for the machine to accomplish multiple state transitions with the same input symbol remaining current. The other point is that, by the very virtue of the state transitions, the machine always "knows" what it has seen previously. In other words, you could say, "If the machine is in state X, then the last N characters have to be the following . . . ." This is an extremely important characteristic of a state machine because it affords it the luxury of discarding input symbols once it has used them. (If need be, the

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machine can reconstruct the input stream for the last N characters just from knowing the current state.)

Uses of State Machines

State machines have many uses. The most common, as mentioned earlier, is in compiler writing, where they are typically used in the lexical analysis and the parsing phases of compilation. There are also programs (most notably YACC) that produce a state machine from a formal definition of a language. Database management systems (query languages) also rely heavily upon state machines.

I have used state machines on numerous occasions, most recently when I was asked to write a program that would extract information selectively from a continuous, on-line data stream. The input was being produced by a PBX that generated call-usage and call-summary reports. The application required that only selected data, from a subset of the reports, be extracted and stored for further processing. The obvious difficulty was remembering, at any given point, which of the many reports were being read and what data to extract. I was able to write such a program quickly and efficiently by modeling the events within the framework of a state machine.

KMP Algorithm

The Knuth-Morris-Pratt (KMP) algorithm accomplishes pattern matching through the use of a state machine. Using this technique, you can efficiently construct a finite automaton for a given pattern string. Moreover, you can then use the machine to test quickly for an occurrence of the pattern in subject strings. The algorithm is really divided into two sections: the first produces the state machine (transition table) derived from its pattern arguments; the second compares the compiled pattern with subject strings.

The transition table is constructed in a straightforward manner. It has an initial or start state, followed by one or more transition states that are derived directly from the pattern string. A one-to-one correspondence exists between the pattern characters and the generated machine states. These are then followed by an accept state. Refer to the function *inits( )* in Listing Three, page 106, for an example.

The second part of the algorithm uses the transition table to make comparisons with input strings. It begins processing in the start state and then iteratively compares the current state information with the corresponding subject string character. If the comparison shows them to be equal, the machine moves to the next state; if they are not equal, the strings are not identical and the machine halts. If the machine reaches the accept state at the same time as it exhausts the subject string, it halts and accepts the input (the pattern and subject match).

Let's take a close look at the operation of the algorithm. For this example, assume a pattern string $P = p_1 p_2 p_3 \ldots p_n$ and an input string $I = i_1 i_2 i_3 \ldots i_n$. The machine begins in state 0 with its read head pointing at i_1.

If the first input token, i_1, is not equal to p_1, then the machine remains in state 0. If $i_1 = p_1$, then the machine advances to state 1. In both cases, the read head is advanced and the current input token is discarded. The machine continues in this fashion as long as the current input symbol matches the pattern character of the current state.

To generalize, suppose that, after having read the input symbols $i_1 i_2 i_3 \ldots i_k$, the machine is in state j. That means that the last j tokens of the input stream are equal to $p_1 p_2 p_3 \ldots p_j$, the first j tokens of the pattern string. If $i_{k+1} = p_{j+1}$, then the machine enters state j+1 and advances the read head. If $i_{k+1} <> p_{j+1}$, then the machine must recover—that is, it must begin to look for an occurrence of the pattern string at the next logical input position. It cannot however, just blindly enter state 0 and resume processing with the next (current) input token; it could miss an occurrence of the pattern beginning at locations $i_{(k-j)+1}$ or $i_{(k-j)+2}$. And, although possible (as stated previously), it is extremely inefficient to have the machine reconstruct and reprocess portions of the input stream. What the machine must do, therefore, is "shift" the pattern forward so that it lines up with some portion of the input stream already processed.

Figure 1, below, shows an example of how this works. If the next subject character, X, is not an A, then the state machine would move the pattern forward as in Figure 2, below. Consequently, it saves the expense of having to compare the pattern beginning at the first B in the subject string. Also, because the states effectively "remember" the last n symbols, the machine is not forced to backtrack over the input stream. (As mentioned earlier, this feature lets the machine discard input tokens once it has read them.)

To accomplish this algorithmically, the machine employs a failure function, f(j), which is defined as returning the largest s (smaller than j) such that $p_1 p_2 p_3 \ldots p_s$ is a suffix of $p_{j-s+1} p_{j-s+2} p_{j-s+3} \ldots p_j$. That is, $p_1 p_2 p_3 \ldots p_s = p_{j-s+1} p_{j-s+2} p_{j-s+3} \ldots p_j$.

Before I demonstrate how to compute the failure function, I'll explain how it will be used. Given the pattern string P=aabbaab, the values of the failure function will be as shown in Figure 3, below.

Suppose that the machine is again in state j, having read $i_1 i_2 i_3 \ldots i_k$. Further, suppose that $i_{k+1} <> p_{j+1}$. The machine will apply the failure function in the following manner:

```
Pattern:       |ABCABC|   A . . .
Subject:    . . |ABCABC|   X
```

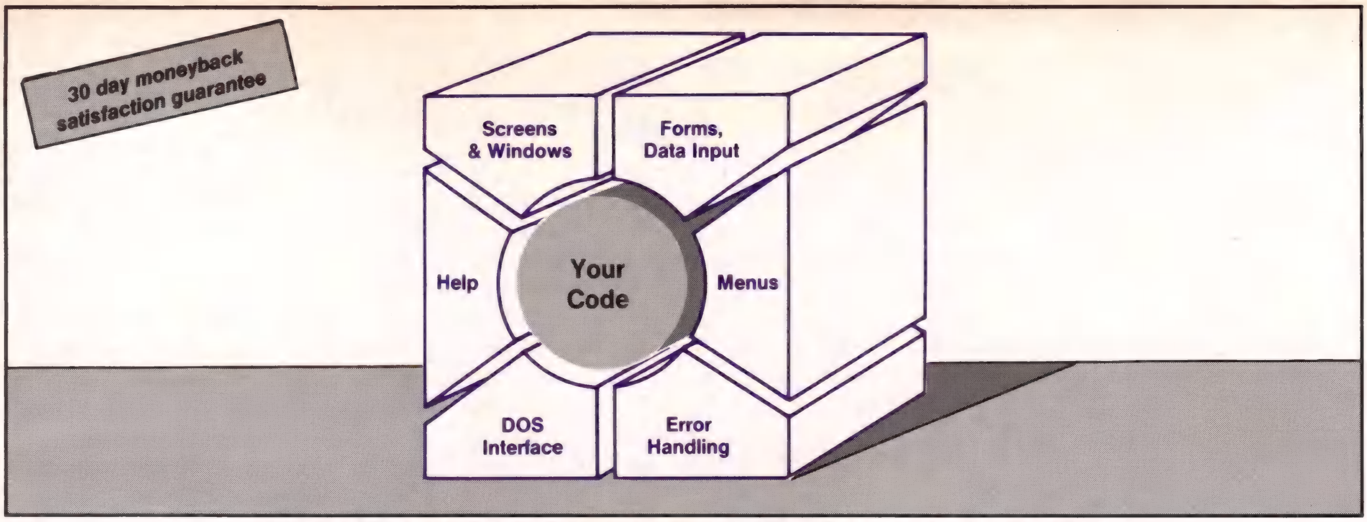
Figure 1: *Before the comparison*

```
Pattern:             |  ABC  |  ABCA . . .
Subject:   . . . ABC|  ABC  |  X . . .
```

Figure 2: *After the comparison*

```
STATE      | 1 | 2 | 3 | 4 | 5 | 6 | 7 |
--------   | --- | --- | --- | --- | --- | --- | --- |
F(STATE)   | 0 | 1 | 0 | 0 | 1 | 2 | 3 |
```

Figure 3: *Values of the failure function for the pattern string P=aabbaab*



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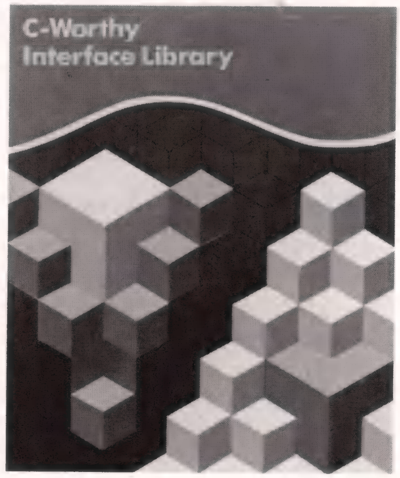

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(continued from page 47)

Step 1: If u = f(j) and $i_{k+1} = p_{u+1}$, the machine enters state u+1 and advances the read head.
Step 2: If f(j) <> 0, then j = f(j) and repeat step 1.
Step 3: If f(j) = 0 and i_{k+1} <> p_1, then the state is reset to 0 and the read head is advanced.

For example, given a pattern P=aabbcc and an input I=aabbaabbcc, the machine would undergo the sequence of transitions shown in Figure 4, right. Notice that in step 5 the pattern was shifted to the third a of the input stream, where the search was resumed.

The failure function is implemented as a table that is created in a manner analogous to its use. It begins with f(1) = 0, by definition. The next steps are easiest to explain by way of an example.

Suppose you have computed f(1), f(2), f(3), . . ., f(j) and that f(j) = i. To compute f(j+1), you compare p_{j+1} with p_{i+1}. If they are equal, then f(j+1) = f(j) + 1. This is because, $p_1 p_2 p_3 \ldots p_i p_{i+1} = p_{j-i+1} p_{j-i+2} p_{j-i+3} \ldots p_j p_{j+1}$. If p_{j+1} <> p_{i+1}, set j = f(j) and repeat the previous step. Continue in this manner until a given $p_{j+1} = p_{i+1}$ or j = 0. Example 1, page 50, contains a pseudocode description of the algorithm.

Modifications to the KMP Algorithm

I wanted to use wildcard characters in my findcmd program, and because I could assume a fixed-length subject string (the length of DOS file names), I dispensed with the failure states. (In applications in which the subject strings are lengthy, failure states greatly increase the efficiency of the algorithm and should be implemented.) I also needed to use a backtracking facility to implement the asterisk operator—I will explain more about this when I discuss the program itself.

I also took the liberty of changing the interpretation of the wildcard characters and the DOS notion of the dot (.) file name extension. As in DOS, a question mark (?) in a pattern positionally matches any one character in a subject string. The asterisk (*), however, functions as a true regular-expression operator (à la Unix), matching zero or more characters. For example, the pattern *m*a*x* matches *max*, *maax*, and *mxaxx*, whereas the pattern *m?a?x* matches only *mxaxx*. Note that you can use more than one asterisk in a pattern (as long as they are not juxtaposed). Finally, a dot (.) in a file name is not treated specially; it is handled in the same manner as is any other valid file name character.

Implementation

I have divided the source code for findcmd into three modules, both as an aid to presentation and to simplify development. The file main.c (Listing One, page 92) contains the driving code of the program. It loops through each pattern (parameter) supplied on the command line; compiles that pattern into a state machine; then steps through each component of the path, comparing the compiled pattern with every file contained in that directory.

Step	Input	Curr State	Trans State	Notes
0	–	0	–	Initial
1	a	0	1	
2	a	1	2	
3	b	2	3	
4	b	3	4	
5	a	4	1	Failure
6	a	1	2	
7	b	2	3	
8	b	3	4	
9	c	4	5	
10	c	5	6	
11	–	H	–	Accept

Figure 4: *The sequence of transitions given a pattern P=aabbcc and an input I=aabbaabbcc*

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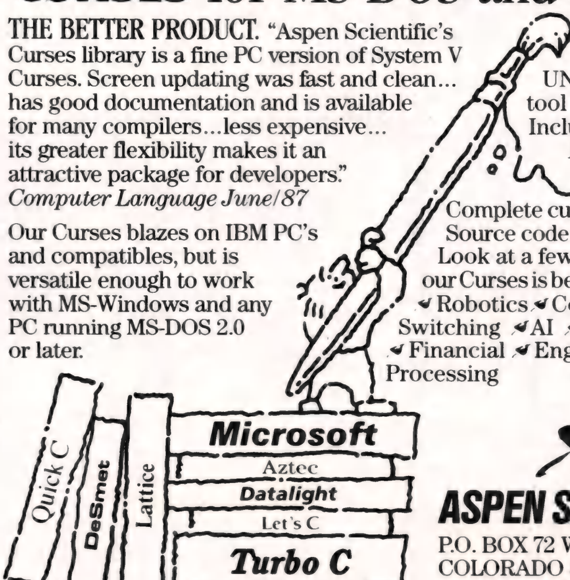

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(continued from page 49)

It then displays every file that successfully matched the pattern string in a manner analogous to Unix's *ls −l* command.

There are two important points to note. The program inserts the current directory (.) at the beginning of the path string to mimic the order in which DOS searches for commands. You should omit this in Unix ports of the program. The program also tests for a trailing backslash in several places in the code. This is largely for aesthetic reasons but it also mitigates DOS' tendency to "cough" when presented with double backslashes in its directory search functions.

Main.c also contains several ancillary routines. The function *nextdir( )* parses each directory segment of the *path* variable into individual strings; *putfile( )* prints, in a formatted manner, all the pertinent information about each successfully matched file; and *fdosdte( )* converts an internal DOS date into a formatted ASCII string.

The second module, dos.c (Listing Two, page 94), contains the two DOS-dependent functions *firstf( )* and *nextf( )*, which are used to access DOS Find First (*4EH*) and Find Next (*4FH*) system calls. In addition, *firstf( )* sets the disk transfer address to point to a C structure using the DOS system call Set Disk Transfer Address (*1AH*). In order to ensure the validity of the pattern matching operation, you need to gain access to every file in a directory. You therefore need to set the DOS search pattern to *.* (match all) and set the *CX* register to request all types of files (system, hidden, and so on). This module contains the only compiler-dependent piece of code in the program.

The third file, state.c (Listing Three) contains the code for the routines *inits( )* and *state( )*. The first function, *inits( )*, compiles the pattern strings into a state-machine format. It functions in a straightforward manner and is simple to understand. The other function, *state( )*, is slightly more subtle. The basic operation of the routine is simple: while in each state, it compares the search string with the pattern and, if they are equal, effects a transition to the next state; if the search string and pattern are not equal, it halts and returns an indicative value. If it makes transitions as far as the end state and exhausts the search string, it returns a value indicating a match.

This procedure works quite well for patterns that do not contain any metacharacters (regular-expression operators). The addition of the question mark (*?*) operator (match any one character) is also straightforward because it really functions as a placeholder. It is only with the asterisk (*) operator (match zero or more repetitions of any character) that a problem arises.

Consider the pattern *m*ax*. The basic algorithm would be able to match this pattern successfully with the search strings *max* or *mmrax*. But what would happen with the search string *maaaax?* If you are not careful,

```
procfindfail()
begin
    f[0] := 0;
    for( j := 2 to N )
    do
        i := f[ j-1 ];
        while( p[j] <> p[i+1] AND i > 0 )
        do
            i := f[i];
        end while;
        if( p[j] <> p[i+1] AND i = 0 )
        then
            f[j] := 0;
        else
            f[j] := i + 1;
        end if;
    end for;
end proc;
```

***Example 1.** Pseudocode description of the failure*

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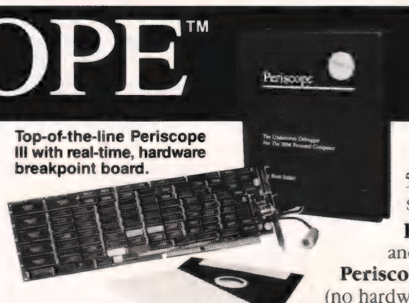

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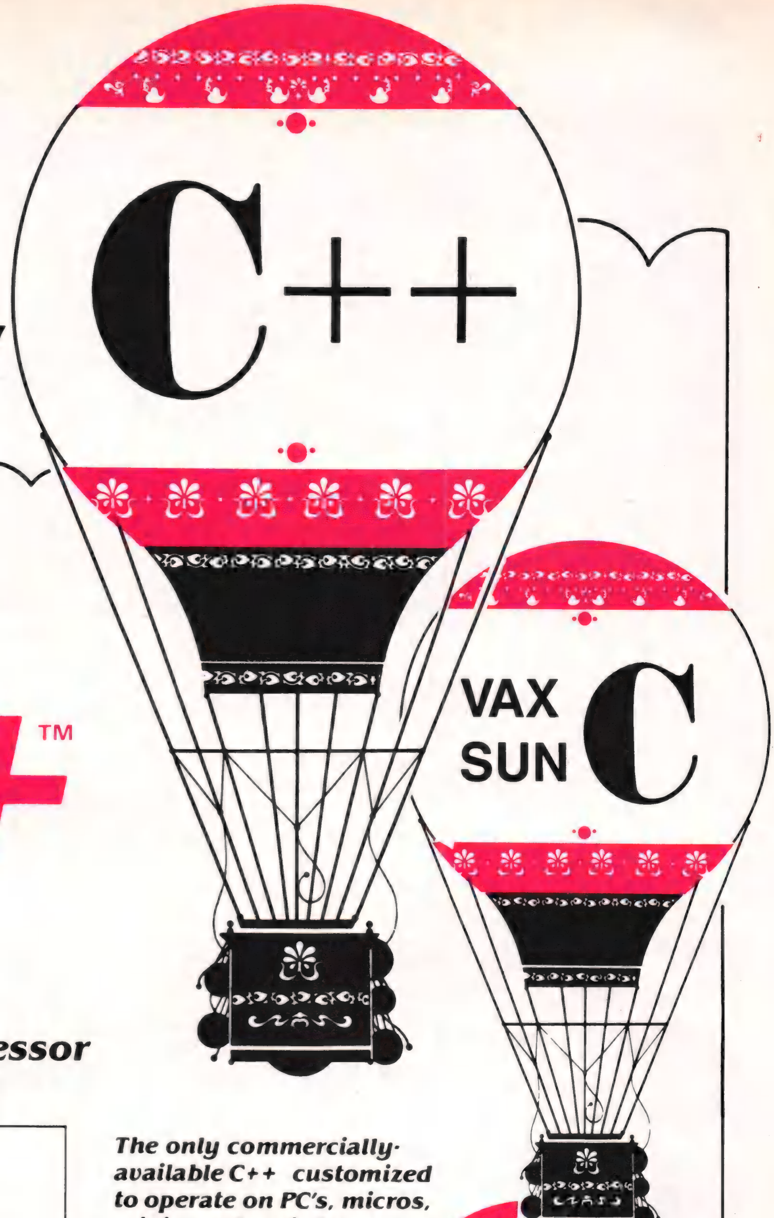

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PATTERN MATCHING
(continued from page 50)

state( ) will return a "no-match" indication when it compares *maa* with *max*. If you provide the function with a backtracking capability, however, when it encounters a no-match condition, it will be able to restore the environment to a previously saved state (actually one subject string character beyond the saved position) and resume the search.

I implemented the backtracking feature using a stack that lets the function store (and recall) state information for patterns containing one or more asterisks. Each time it encounters the wildcard operator (*case '*':*), *state( )* saves (pushes) both the current state and a pointer into the subject string onto the stack. Then, if it should encounter a no-match condition (*default:*), it can check the contents of the stack, and if it is nonempty, restore (pop) a saved state and continue processing.

The file findcmd.h (Listing Four, page 107) contains all the global definitions, declarations, and macros referenced in the other three files.

Invoking the program is simple—just type *findcmd* followed by a list of patterns (files) for which you want it to search. Patterns can be as simple or complex as you wish. For example, if you want to find the directory that contains your favorite editor, just type *findcmd ed.exe*, and the program will search each directory component of your *path* variable for the file ed.exe. If you cannot remember whether the file is in .com or .exe format, type *findcmd ed.**, *findcmd ed**, or *findcmd ed????*. The latter two examples highlight the fact that findcmd, unlike COMMAND.COM, treats the period as an ordinary character in the file name. That is, a dot does not delimit the scope of the asterisk operator.

Portability

The program was written under MS-DOS using Version 3.0 of the Mark Williams C compiler. If you use another compiler, the only nonportable code is contained in the file dos.c. This file should not be too difficult to deal with, however. Most popular C compilers have a method of accessing DOS system facilities—just modify the two

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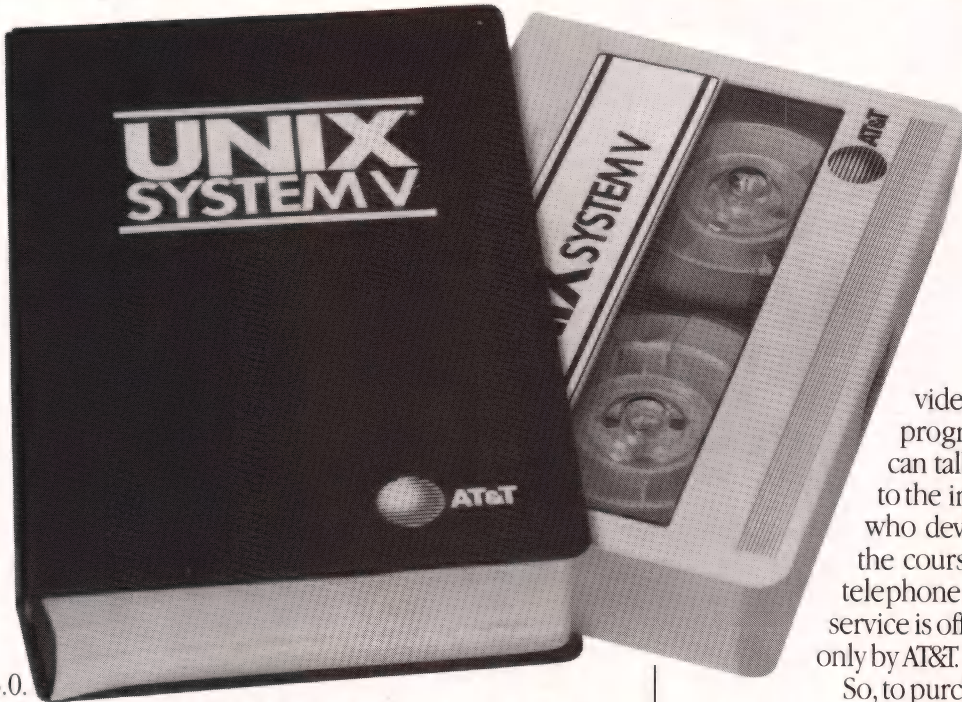

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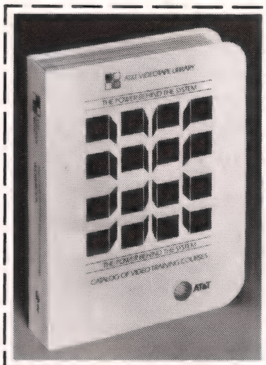

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Macro execution window	No	No	No	Yes
Pop-up menus	No	No	No	Yes
Execute DOS commands	Yes	Yes	Yes	Yes
Automatic processing of Compiler errors	Yes	No	No	Yes
"Cut and paste" buffers	1	1	1	36
Undo line changes	Yes	No	No	Yes
Paragraph justification	No	No	No	Yes
Convert to/from WordStar	No	No	No	Yes
On-line calculator	No	No	No	Yes
Configurable Keyboard	Hard	No	Hard	Easy
43 line EGA support	Yes	No	No	Yes
Manual size/index	250/No	42/no	469/Yes	380/Yes
Benchmarks in 120K File:				
2000 replacements	1:15 min	34 sec	1:07 min	6 sec
Pattern matching search	20 sec	Cannot	Cannot	2 sec
Pattern matching replace	2:40 min	Cannot	Cannot	11 sec

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PATTERN MATCHING
(continued from page 52)

C functions to work within your compilation environment.

For those who wish to port the program to a Unix system, the same caveat applies: just modify the functions in dos.c. You will have to completely rewrite the routines but, again, this should not be difficult. A good description of how to access a Unix directory is in Brian Kernighan and Rob Pike's *The Unix Programming Environment* (see bibliography).

Extensions

This program can accommodate several extensions. One that I like (I have implemented it on both my PC and Unix versions) is the addition of a switch on the command line to direct the program to access an alternate environment variable in lieu of *path*. This is useful if you tend to keep application source files scattered all over your disk. You could set this alternate variable (in the same format as you would your *path*) to point to all your source code directories. Then, by setting one switch on the command line, findcmd can search an alternate set of directories for you.

You can modify the functions contained in state.c for independent use by incorporating the routine *inits( )* into a separate program. This program's only function would be to compile pattern strings and store the results in a file. Then, at execution time, a program performing the actual comparisons would not incur the expense of "compiling" the patterns—it would just read them from disk. This would operate in a manner similar to the Unix utilities *regcomp( )* and *regex( )*.

Additional regular-expression operators could be incorporated into the algorithm to add more power and flexibility to search patterns. I have found, however, that the operators now included in the program are adequate for everyday use (and there are better algorithms than KMP for recognizing complex regular expressions).

Finally, consider how simple the changes would be to transform this program into an *ls* command (as if you needed another one!).

Conclusions

In any development environment, no single programming tool is sufficient to satisfy every need. Any instrument or methodology that can spare us from the tedium of a routine chore, or enable us to become more productive, should be embraced with open arms. State machines are just such a tool and can benefit all programmers.

Availability

All the source code for articles in this issue is available on a single disk. To order, send $14.95 to *Dr. Dobb's Journal*, 501 Galveston Dr., Redwood City, CA 94063, or call (415) 366-3600, ext. 216. Please specify the issue number and format (MS-DOS, Macintosh, Kaypro). If you would rather not have to retype the entire program send me a check for $6 and I will mail you an MS-DOS floppy (360K format) containing the program and source code.

Bibliography

Aho, Alfred V; Hopcroft, John E.; and

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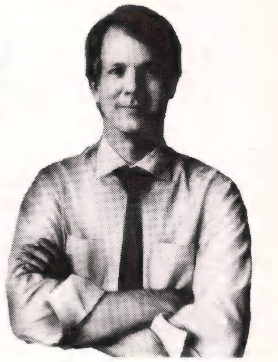

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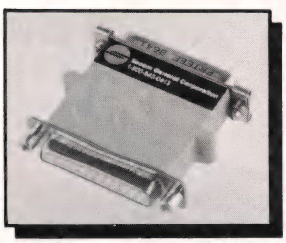

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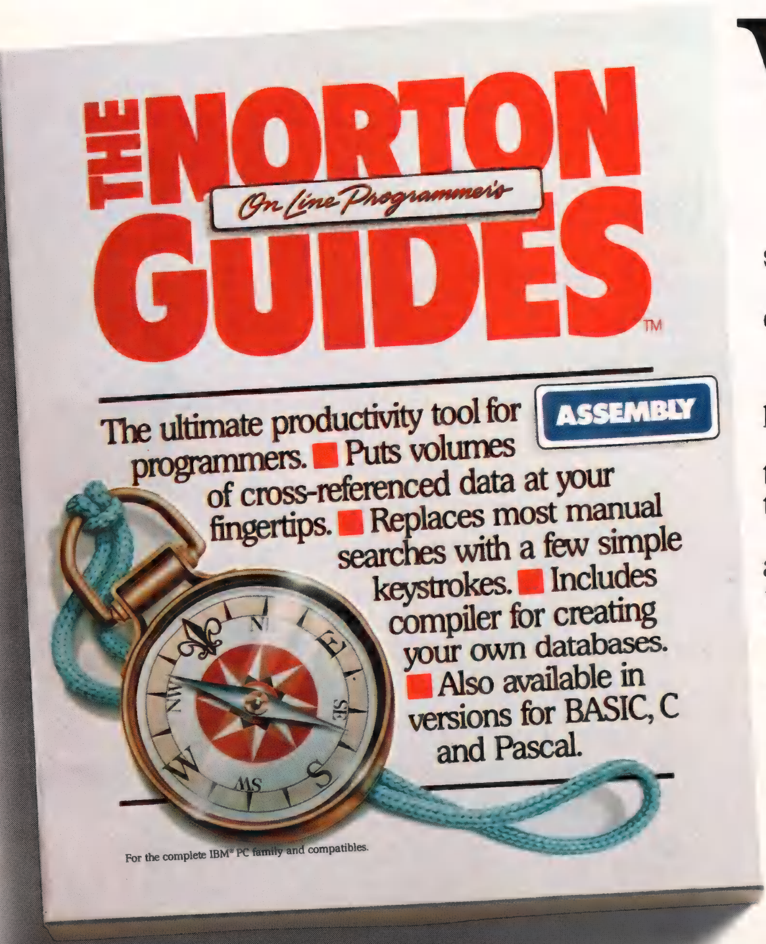

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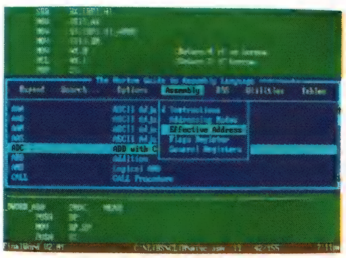

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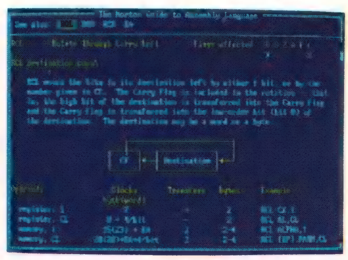

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***** file ALAPDEFS.A *****

; AALAPdefs.a contains all the special definitions which were not
; needed for .MPP .
;
; .BPP et al should now use unmodified versions of:
;                 {AIncludes}atalkequ.a
;                 lapdefs.a
;                 vardefs.a
;
; Created 31 Mar 87   reb
;
; AALAP constant defs
;
MaxLAPFrmLen EQU    586+13+3+2          ; DDP data + DDP hdr + LAP hdr + CRC
FrameChar    EQU    $A5                 ; the Framing Char
qFrmChar     EQU    -91                 ; for moveq instructions
DLE          EQU    $10
Xoff         EQU    $13
Xon          EQU    $11

lapIM        EQU    $86                 ; I aM
lapUR        EQU    $87                 ; yoU aRe (sorry for these names...)
qlapIM       EQU    -122
qlapUR       EQU    -121

noansalrt    EQU    -15998
portncalrt   EQU    -15997

; Added constant return value for AALAP --
noAnswer          EQU     -95          ; same as excessCollsns in real AtalkEqu

AAOfst            EQU     10000      ; 0 or 10000 (for final version)

;+ MPP (Status calls to NBP, DDP and AALAP)

GetStats          EQU     400        ; (ABLAP) get the statistics
GetMyName         EQU     AAOfst+255 ; get the name of the ATalk driver
(AALAP)
GetChar           EQU     AAOfst+254 ; get the most recently received char
(AALAP)
GetLAPStatus      EQU     AAOfst+253 ; return AALAP status  (AALAP)

;+ MPP (Control calls to NBP, DDP, and AALAP)

FirstAPP          EQU     AAOfst+237 ; First APP control call
DoWarnings        EQU     AAOfst+237 ; Put up the specified alerts
(AALAP)
PutChar           EQU     AAOfst+238 ; Loop 'til TBMT, then output the char
(AALAP)
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(continued on page 62)

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Listing One *(Listing continued, text begins on page 18.)*

```
ReInitAALAP     EQU     AAOfst+239 ; ReInitialize the AALAP variables & SCC
(AALAP)
GetNNNN         EQU     AAOfst+240 ; Do NNNN using SysNetNum and sysLAPAddr
(AALAP)
SetBaud         EQU     AAOfst+241 ; Set the baud rate of the SCC
(AALAP)
LastAPP         EQU     AAOfst+241
          EJECT
;
; LAP variables
;
WDSPtr       EQU     MPPVarsEnd          ; (4) WDS pointer saved here on writes
LAPWrtRtn    EQU     WDSptr+4            ; (4) return adrs of LAPWrite caller
SaveA45      EQU     LAPWrtRtn+4         ; (8) A4 and A5 saved here on interrupt
SaveDskRtn   EQU     SaveA45+8           ; (4) DskRtnAdr saved here for
PollProc
SavePS       EQU     SaveDskRtn+4        ; (4) in AALAP, the real PollProc's
address
SaveBIn      EQU     SavePS+4            ; (4) .BIN DCE saved here (for close)
SaveBOut     EQU     SaveBIn+4           ; (4) .BOUT DCE saved here (for close)
SaveVects    EQU     SaveBOut+4          ; (16) SCC interrupt vectors saved
here
SaveRegs     EQU     SaveVects+16        ; (20) Registers saved here across
PollProc

;
; Variables for Lisa/Mac hardware differences
;
VAVBufA      EQU     SaveRegs+20         ; Pointer to VIA or a $FF word
STLth        EQU     6                   ; Size of STData area
VSTData      EQU     VAVBufA+4           ; Data string to SCC after send
VDisTxRTS    EQU     VSTData+1           ; This is the DisTxRTS byte
EndOrigStuff EQU     VSTData+STLth       ;

;
; AALAP varibles
;
tWDSptr      EQU     EndOrigStuff+2      ; (4) WDS ptr of frame being tx
qWDSptr      EQU     tWDSptr+4           ; (4) WDS of a queued DevMgr frame
LastXmit     EQU     qWDSptr+4           ; (4) Ticks at time of last char sent
LastRcv      EQU     LastXmit+4          ; (4) Ticks at time of last good
received frame
LAPStash     EQU     LastRcv+4           ; (4) Pointer to next received char's
place
LAPFetch     EQU     LAPStash+4          ; (4) Pointer to next char to xmit
LAPInBuf     EQU     LapFetch+4          ; (4) Pointer to the LAP input buffer
IMURwds      EQU     LAPInBUf+4          ; (8) WDS for IM or UR frames
BusyBuf      EQU     IMURwds+8           ; (16) Holds up to 16 chars rcvd while
doingRead
BusyStash    EQU     BusyBuf+16          ; (4) pointer to next space in BusyBuf
BusyFetch    EQU     BusyStash+4         ; (4) pointer to next char to remove
IMURbuf      EQU     BusyFetch+4         ; (8) Holds IM or UR (starting at odd
adrs)
InputCRC     EQU     IMURBuf+8           ; (2) CRC for the receiver
OutputCRC    EQU     InputCRC+2          ; (2) CRC for the transmit side
RcvdLen      EQU     OutputCRC+2         ; (2) Number of chars received
TxCount      EQU     RcvdLen+2           ; (2) Number of char's transmitted
CRCBuf       EQU     TxCount+2           ; (2) Two bytes for the CRC for
xmission
RandomSeed   EQU     CRCBuf+2            ; (2) Seed for random number generator
LastRxCh     EQU     RandomSeed+2        ; (2) Lsbyte is last rcvd char, else
$FFFF
AALAPbaud    EQU     LastRxCh+2          ; (2) Current baud rate of the LAP
SentChar     EQU     AALAPbaud+2         ; (1) True if TxNextCh sent a char
nFrmChr      EQU     SentChar+1          ; (1) True if we must send a FrameChar
nCRC         EQU     nFrmChr+1           ; (1) True if we must send the CRC
EscIn        EQU     nCRC+1              ; (1) Escaping flag for the receiver
EscOut       EQU     EscIn+1             ; (1) Transmitter is sending an escaped
char
RcvdXoff     EQU     EscOut+1            ; (1) We received Xoff
AALAPup      EQU     RcvdXoff+1          ; (1) true if we've handshook IM & UR
AALAPstuck   EQU     AALAPup+1           ; (1) true if we have NNNN conflict
InpState     EQU     AALAPstuck+1        ; (1) 0 = idle; <> 0 = in a frame
stillBusy    EQU     InpState+1          ; (1) true if still processing a read
nXon         EQU     stillBusy+1         ; (1) true if we sent Xoff
SendingIMUR  EQU     nXon+1              ; (1) true if sending AALAP control frame

 _AssumeEq    (InpState+1),stillBusy         ; tst.w InpState(A4) in
 _AssumeEq    (InpState**$FFFFFFFE),InpState ;   myPollProc fails otherwise

             IF      debug THEN          ; doing statistics
```

(continued on page 65)

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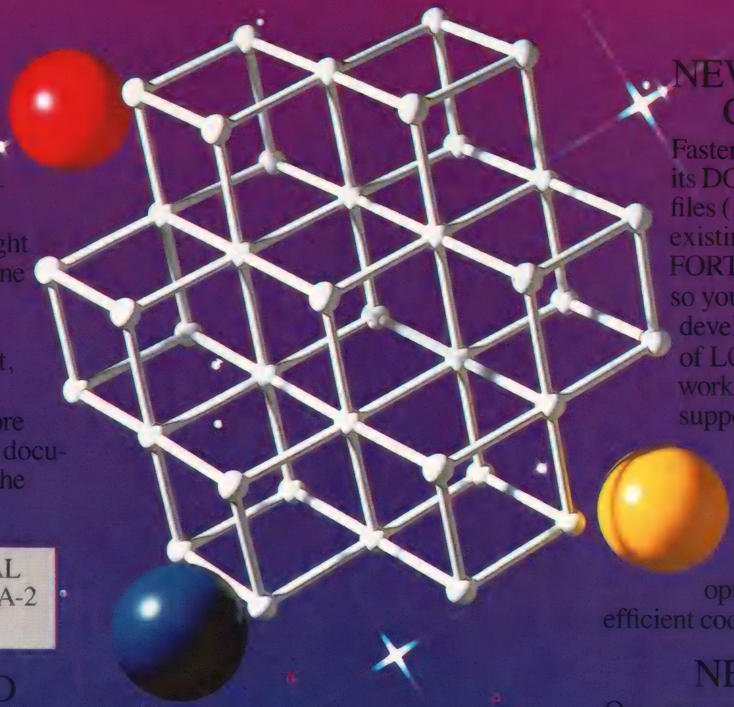

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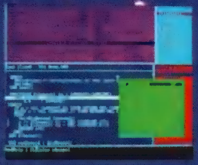

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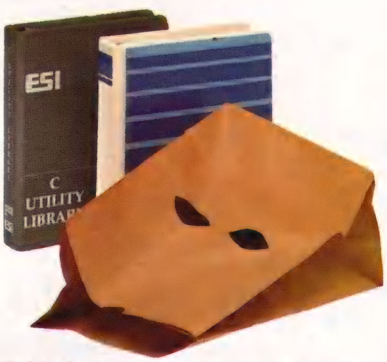

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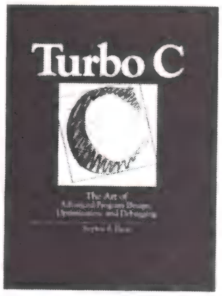

Turbo C: The Art of Advanced Program Design, Optimization and Debugging

by Stephen R. Davis

Overflowing with example programs, this book fully describes the techniques necessary to skillfully program, optimize, and debug in Turbo C. Every topic and Turbo C feature discussed is fully demonstrated in Turbo C source code examples. Advanced topics such as pointers; direct screen I/O; inline statements in Turbo C; and how to intercept and redirect BIOS calls are all covered in depth. The author further demostrates these advanced topics by writing a RAM resident pop-up program in Turbo C. In addition, the author fully outlines the differences between Unix C and Turbo C; the transition from Turbo Pascal to Turbo C; and the superset of K&R C features implemented in Turbo C and included in the proposed ANSI C standard.

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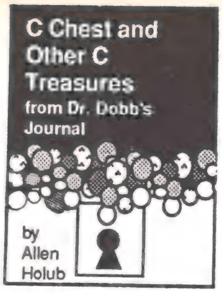

C Chest and Other C Treasures from Dr. Dobb's Journal

Edited by Allen Holub

This comprehensive anthology contains the popular "C Chest" columns from *Dr. Dobb's Journal of Software Tools,* along with the lively philosophical and practical discussions they inspired, and other information-packed articles by C experts.

Topics covered include: pipes, wild-card expansion, and quoted arguments; sorting routines; command-line processing; queues and bit maps; utilities such as *ls, make,* and *more;* expression parsing; hyphenation; IBM cursor control and an Fget that edits; redirection; accessing IBM video display memory; trees; an AVL tree database package; directory traversal; sets; shrinking .EXE file images; hashing, expressions, and Roman numerals; and statistical applications of digital low-pass filters.

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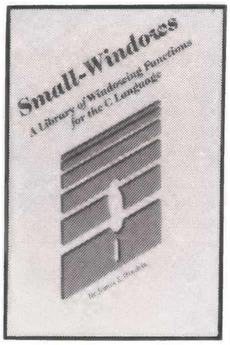
Small-Windows: A Library of Windowing Functions for the C Language

by James E. Hendrix



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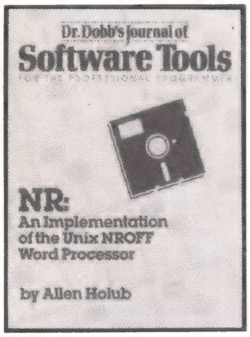

NR: An Implementation of the Unix NROFF Word Processor

by Allen Holub

NR is a text formatter that is written in C and compatible with Unix's NROFF. Complete source code is included in the **NR** package so that it can be easily customized to fit your needs. **NR** also includes an implementation of the *-ms* (manuscript) macro package and an in-depth description of how *-ms* works. **NR** does hyphenation and simple proportional spacing. It supports automatic table of contents and index generation, automatic footnotes and endnotes, italics, boldface, overstriking, underlining, and left and right margin adjustment. **NR** also contains:

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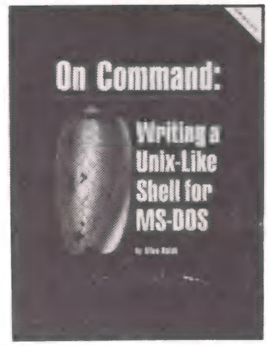
On Command: Writing a Unix-Like Shell for MS-DOS

by Allen Holub



This book and ready-to-use program demonstrate how to write a Unix-like shell for MS-DOS, with techniques applicable to most other programming languages as well. The book and disk include a detailed description and working version of the Shell, complete C source code, a thorough discussion of low-level MS-DOS interfacing, and significant examples of C programming at the system level.

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by Allen Holub

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Listing One *(Listing continued, text begins on page 18.)*

```
XmitCount    EQU    SendingIMUR+1
XOFFTOcount  EQU    XmitCount+4
OVRcount     EQU    XOFFTOcount+4
RcvIntCount  EQU    OVRcount+4
XOFFcount    EQU    RcvIntCount+4
XONcount     EQU    XOFFcount+4
LongFrame    EQU    XONcount+4
ShortFrame   EQU    LongFrame+4
FrmCount     EQU    ShortFrame+4
NoHandCnt    EQU    FrmCount+4
CRCCount     EQU    NoHandCnt+4
LenErrCnt    EQU    CRCCount+4
BadDDP       EQU    LenErrCnt+4
PPCount      EQU    BadDDP+4
PPXoffCnt    EQU     PPCount+4
DeferXmit    EQU     PPXoffCnt+4
ABVarsEnd    EQU    DeferXmit+4
             ELSE
ABVarsEnd    EQU    SendingIMUR+1          ; end of AALAP variables
             ENDIF

***** file MPP.A *****

... section removed ...

;_____________________________________________________________________
;
; SCCConfig - set up the SCC for AppleBus
;_____________________________________________________________________

SCCConfig    LEA     OpenTbl,A0          ; A0 -> (common) open table
             CMP.B   #$FF,MacTypeByte    ; Mac or Lisa?
             BNE.S   @10                 ; Branch if Mac - configure it
             BSR     ToSCC               ; Configure SCC to major settings
             LEA     LOpenTbl,A0         ; A0 -> Lisa open table
@10          BRA     ToSCC               ; Configure SCC and return

... section removed ...

ToSCC        MOVE.L  SCCWr,A3            ; Point to SCC port B write registers
             IF      PortA THEN
             ADDQ    #ACtl,A3            ; Add in port A offset
             ENDIF
@10          MOVE    (A0)+,D0            ; Get next register number / control
word
             BEQ.S   CloseRTS            ; Zero is terminator
             MOVE.B  D0,(A3)             ; Put out register number
             ROR     #8,D0               ; Pickup control word
             MOVE.B  D0,(A3)             ; Set to SCC
             BRA.S   @10                 ; And keep going

... section removed ...

;_____________________
;
; Initialization tables
;_____________________

;
; SCC Initialization table - common between Mac and Lisa
; Entry format: .BYTE control-value, control-reg-number
; Taken from the Zilog SCC Application note, 00-2957-02

OpenTbl      DC.B    ResetOurPort,9      ; ($40 or $80) Reset port
             DC.B    $44,4               ; x16 clock, 1 stop, no parity
             DC.B    $0,2                ; Interrupt vector = $00
             DC.B    $C0,3               ; Rx is 8 bits, disable Rx
             DC.B    $E2,5               ; Tx is 8 bits, Disable Tx; DTR, RTS
on
             DC.B    $0,6                ; No address
             DC.B    $0,7                ; No Flag character
             DC.B    $0,10               ; NRZ
             DC.B    $56,11              ; Tx & Rx clock from BRG
             DC.B    $2,14               ; BRG source = PCLK, BRG off
; enables
             DC.B    $3,14               ; BRG on
             DC.B    $C1,3               ; Rx on
             DC.B    $EA,5               ; Tx on
; Interrupt controls
             DC.B    MouseInts,15        ; enable DCD ints (for mouse)
```

(continued on next page)

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Listing One *(Listing continued, text begins on page 18.)*

```
            DC.B    $10,0               ; reset external ints
            DC.B    $10,0               ; reset external ints (twice)
            DC.B    $13,1               ; Tx, Rx, Ext int enable
            DC.B    MIE,9               ; Master Interrupt Enable
            DC.W    0                   ; *** End of table ***

            IF      RAM THEN            ; Only need Lisa table if RAM-based
;
; SCC initialization table for Lisa
; Port A uses PCLK (@4.0 MHz TTL) to drive BRG; Port B uses 3.6864 MHz Xtal
;
            IF      PortA THEN          ; configuration for Port A
LOpenTbl    DC.B    $00,14              ; turn off BRG
            DC.B    $6A,5               ; enable TX, RTS; DTR low
            DC.B    $56,11              ; TTL clock, tx and rx use BRG
            DC.B    $02,14              ; Use PCLK to feed BRG, BRG off
            DC.B    $03,14              ; BRG on
            DC.W    0
            ELSE                        ; configuration for PortB
LOpenTbl    DC.B    $00,14              ; turn off BRG
            DC.B    $6A,5               ; enable TX, RTS; DTR low
            DC.B    $D6,11              ; Crystal clock, tx and rx use BRG
            DC.B    $00,14              ; Use crystal to feed BRG, BRG off
            DC.B    $01,14              ; BRG on
            DC.W    0
            ENDIF

;
; Mac initialization data (first is the post-transmitting SCC string)
;
MacInitData DC.B    5,MDisTxRTS         ; ($60) Turn off drivers
            DC.B    14,ResetClks        ; ($41) Reset missing clocks flag
            DC.B    3,EnbRxSlv          ; ($DD) Enable receiver
            DC.W    $2100               ; SR to enable SCC interrupts
            DC.B    AbortDelay,0        ; Delay to send out abort bits (3.2B)
            IF      RAM THEN
;
; Lisa initialization data
;
LisaInitData DC.B   5,LDisTxRTS         ; ($E2) Turn off drivers
            DC.B    14,ResetClks        ; ($41) Reset missing clocks flag
            DC.B    3,EnbRxSlv          ; ($DD) Enable receiver
            DC.W    $2500               ; SR to enable SCC interrupts
            DC.B    34,0                ; Just delay this much on Lisa (3.2B)
            ENDIF

***** file LAP.A *****

;__________________________________________________________________________
;
; LAP.TEXT - the LAP part of AALAP
;
; April-August, 1984
; Alan Oppenheimer and Larry Kenyon
;
; Rich Brown, Dartmouth College
; May 1987
;
; Version 1.2a6 Created qWDSptr to point at queued WDS  21 May 87   reb
; Version 1.2a5 Always check that TBMT is true before sending  19 May 87   reb
; Version 1.2a4 TintHnd, VBLHnd, RintHnd now call TxNextCh; only TintHnd
; clears interrupts (as it should be)   14 May 87   reb
; Version 1.2a3 Prefetching warning dialogs doesn't work; backed out  10 May 87 reb
; Version 1.2a2 tWDSptr now determines whether we're sending a frame;
; DoWarn now doesn't read the resource file  8 May 87   reb
; Version 1.2a1 Removed queueing from LAPWrite.  LAPWrite no longer
; allocates memory, so it won't fail if called from
; interrupt handling.   19 Apr 87   reb
; Version 1.1b2 Changed noAnswer to -95 (so it can be handled like excessCollsns)
; LAPWrite returns noAnswer if AALAP not up; (30 Mar 87)
; GetNNNN  returns noAnswer or PortNotCF;
; Changed LAPWrite to return ddpLenErr if too long
; Version 1.1b1 Fixed PollProc to be more agressive about sucking chars
; from the SCC; added -1 SendChar value (sends Break);
; fix Initcursor bug in Dowarn 16 & 30 Dec 86   reb
; Version 1.1a1 Output an Xoff if called by PollProc during an input message
; 3 Nov 86   reb
; Version 1.0b2  Changed to set up SCC properly for Lisa  15 Oct 86
; (still has intermittent hangups, tho -- not diagnosed)
; Version 1.0b1 Changed last_valid_frame timer to 30 seconds; always send
; UR, even after un-matchable IM address
```

```
; Version 1.0a3 Fixed Status return buffer bug; SetBaud now takes actual
;                    baud rate; added GetLAPStatus call; copy entire message
; Version 1.0A2 Added alerts for NoAnswer, PortNotCf    (17 Jul 86    reb)
; Version 4.2   Int handlers now do IUS etc. more carefully (4 Jul 86)
; Version 4.1   Now escapes either parity Xon and Xoff (21 Apr 86)
; Version 4.0   First cut at AALAP (26 Oct-14 Dec 85)
... section removed ...
;
; COPYRIGHT (C) 1984 APPLE COMPUTER
;_______________________________________________________________________

... section removed ...

;_______________________________________________________________________
;
; MReInit - Control call to reinit AALAP and the SCC
;_______________________________________________________________________

MReInit     bsr.s AALAPWarm            ; Warm start ourselves
            BRA   AbusExit             ; and return
;_______________________________________________________________________
;
; AALAPCold -- cold start for AALAP; called only once
;_______________________________________________________________________

AALAPCold
;
; Allocate the input buffer (This should be alloc above BufPtr, not sysheap)
;
            move.l  #maxLAPFrmLen,D0     ; get an AALAP input buffer
            _newptr ,SYS                 ; from the system heap
            bne.s  WarmRTS               ; exit if bad
            move.l  A0,LAPInBuf(a2)      ; otherwise save its pointer
;
; Clear out LAP variables
;
            clr.l   WDSPtr(a2)
            clr.l   tWDSptr(A2)
            clr.l   LAPWrtRtn(A2)
            clr.w   SysNetNum(a2)
            clr.b   SysLAPAddr(a2)
            clr.l   SavePS(A2)
            sf      AALAPup(a2)
            sf      AALAPstuck(a2)
;
; Setup SCC for AALAP
;
            BSR     SCCConfig            ; Configure the SCC for Async
AppleTalk
            move    #9600,D0             ; and set up for 9600 baud
            bsr      Set_Baud            ;
;
; Reset all the LAP variables which don't irrevocably change the
; state of the driver.  This routine can be called any time, only
; killing the current message(s) in progress.
;
AALAPWarm   move.l  Ticks,D0
            move.l  D0,LastXmit(a2)
            move.l  D0,LastRcv(a2)
            lea     BusyBuf(a2),A0
            move.l  A0,BusyStash(a2)
            move.l  A0,BusyFetch(a2)
            move.w  #$FFFF,LastRxCh(a2)
            clr.l   tWDSptr(A2)
            clr.l   qWDSptr(A2)
            clr.w   TxCount(a2)
            sf      RcvdXoff(a2)
            sf      InpState(a2)
            sf      EscIn(a2)
            sf      SendingIMUR(A2)
            sf      stillBusy(a2)
            sf      nFrmChr(a2)
            sf      nCRC(a2)
            sf      nXon(A2)
WarmRTS     rts

            EJECT
;_______________________________________________________________________
;
; Status - handle driver status request
;_______________________________________________________________________
```

(continued on next page)

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Listing One *(Listing continued, text begins on page 18.)*

```
            _SUBR                             ; no one better call this...
Status      MOVE.L  MPPVars,A2                ; A2 -> our variables
            MOVEQ   #StatusErr,D0             ; Assume a status error
            lea     CSParam(A0),A1            ; point at the CSParam buffer
            move.w  CSCode(A0),D1             ; and get the CScode

            IF      Stats THEN
            CMP.W   #GetStats,D1              ; Clear stats command?
            BNE.S   @1                        ; check for "What's my Name?" if not
            move.w  CSParam(A0),A1            ; CSParam contains a pointer to buffer
            MOVE    SR,-(SP)
            MOVE    #SCCLockout,SR            ; exclude interrupts to keep stats
clean
            ADD     #StatsStart,A2            ; point to stats we keep
            MOVEQ   #(StatsLgCnt-1),D0
            MOVEQ   #0,D1                     ; zero for faster clearing
@0          MOVE.L  (A2),(A1)+                ; return current value
            MOVE.L  D1,(A2)+                  ; then zero count
            DBRA    D0,@0
            MOVE    (SP)+,SR
            bra.s   AbusExit
            ENDIF

@1          cmp.w   #GetMyName,D1             ; is this a "what's my name" call?
            bne.s   @2                        ; go if not
            Move.l  MPP+18,(A1)+              ; move Pascal string from front of driver
            move.b  MPP+22,(A1)               ; to beginning the buffer (5 chars)
            bra.s   @4                        ; and exit with good status

@2          cmp.w   #GetChar,D1               ; is this a "get last char" call?
            bne.s   @3                        ; go if not
            move.w  LastRxCh(a2),(A1)         ; copy the character (word)
            move.w  #$FFFF,LastRxCh(a2)       ; and flag the character
            bra.s   @4

@3          cmp.w   #GetLAPStatus,D1          ; is this a "get LAP status" call?
            bne.s   AbusExit                  ; go if not
            move.b  AALAPup(A2),(A1)+         ; AALAPup?
            move.b  AALAPstuck(A2),(A1)+;AALAPstuck?
            move.w  AALAPbaud(A2),(A1)        ; What's the baud rate?
@4          clr.l   D0                        ; return good status

AbusExit    MOVE.L  MPPDCE,A1                 ; Make sure A1 has DCE address
AbusExA1    MOVE.L  JIODone,-(SP)             ; This is how we exit (Prime, Control,
Status)
AbusRTS     RTS
            SUBEND  'MYSTATUS'                ; this marks the AbusExit

Prime       BCLR    #DrvrActive,DCtlFlags+1(A1) ; *** V2.0C Fix Mac ROM bug
***
            RTS                                       ; *** V2.0C Fix Mac ROM bug
***
            EJECT
;____________________________________________________________________
;
; MGetNNNN -- Do the NNNN, using the current values of SysLAPAddr and
;             SysNetNum.  Return bad status if it didn't work.
;
; On entry: A2 -> BPP variables
; On exit:  D0 = noErr (0) if we succeeded,
;                PortNotCF (-98) or
;                noAnswer  (-95) if not
;____________________________________________________________________

MGetNNNN    bsr.s   Get_NNNN                  ; Use them just as they are
            bra.s   AbusExit                  ; return from the control calls

tries       EQU     -2                        ; counter for the tries
endtime     EQU     -6                        ; end time

Get_NNNN    _SUBR   6
            move.w  Ticks+2,RandomSeed(a2) ; randomize things
            move.b  SysLAPAddr(a2),D0         ; Node number in D0
            move    SysNetNum(a2),D1          ; Net number in D1
            sf      AALAPup(a2)               ; we're not up yet
            sf      AALAPstuck(a2)            ; and we're not in trouble either
            move    #4,tries(a6)              ; tries counter (4 tries)
@10         move.l  Ticks,D2
            add.l   #30,D2                    ; set endtime to the current time+30
            move.l  D2,endtime(a6)            ; remember the ending time
            moveq   #qlapIM,D2                ; get the lap type
```

```
           move.w   SysNetNum(a2),D1   ; get the Net number
           move.b   SysLAPAddr(a2),D0  ; and the node number
           bsr      SendIMUR           ; and send it
@20        clr      D0                 ; good status if things are OK
           tst.b    AALAPup(a2)        ; did the magic work?
           bne.s    NNNNexit           ; go if so
           tst.b    AALAPstuck(a2)     ; is there an irreconcilable difference?
           bne.s    NNNNstuck
           move.l   endtime(a6),D2
           cmp.l    Ticks,D2           ; otherwise, check the timer
           bpl.s    @20                ; loop if not timed out
           sub      #1,tries(a6)       ; decr the counter
           bgt.s    @10                ; loop if non-zero
           moveq    #noAnswer,D0       ; They don't want to talk
           bra.s    NNNNexit

NNNNstuck  moveq    #PortNotCF,D0      ; They talk but say bad things

NNNNexit   tst.w    D0                 ; set CC
           _Subend  'GETNNNN '         ; and return
           EJECT
;_____________________________________________________________________________
;
; MPutChar -- Kill output and send the char pointed to in the control call
;
; Entry:   A0 -> IOQelement
; Exit:    Return status is 0000  if noErr,
;                          BadIO  if timed out waiting for TBMT
;_____________________________________________________________________________

SendBrk    equu     $12                ; Sends Break (w/RTS) when sent to WR5

MPutChar   bsr.s    Put_Char
           bra      AbusExit           ; and exit

Put_Char    _SUBR
           move.w   CSParam(a0),D0     ; get the character (in an integer)
           bmi.s    @10                ; if it's 0..255,
           bsr      SendChar           ;    output the character
           bra.s    @20                ; and quit

@10        lea      BreakTbl,A0        ;
           move.b   #SendBrk,(A0)      ; set the break bit in WR5
           bsr      ToScc              ;
           move.l   #10,A0             ; wait 10 ticks
           _delay
           move     #$EA,D0            ; Enable Tx, DTR, RTS
           CMPI.B   #$FF,MacTypeByte   ; Mac or Lisa?
           BNE.S    @15                ; Branch if Mac (PortA & PortB are same)
           move     #$6A,D0                     ; Lisa doesn't assert DTR
           @15lea   BreakTbl,A0
           move.b   D0,(A0)              ; and turn the Break off
           bsr      ToSCC
           clr      D0

@20        SUBEND 'MPUTCHAR'

breaktbl   dc.b     0,5      ; THIS WON'T MAKE ROMMABLE CODE
           dc.w     0000
;____________________________________________________________________
;
;  MSetBaud -- send the (integer) value in the CSParamblk to SCC as its Baud
Rate
;  Entry:  A0 -> IOQelement
;  Exit:   noErr if aok
;          -1    if requesting 19,200 baud on a Lisa, port A (cannot be done)
;____________________________________________________________________
; THIS WON'T MAKE ROMMABLE CODE!
BaudConsts  DC.B    2,14               ; turn off BRG (so it doesn't count for
a while)
lsBaudVal   DC.B    0,12               ; LSByte of BRG
msBaudVal   DC.B    0,13               ; MSByte of BRG
BaudSrc     DC.B    0,14               ; turn it on again, with proper baud
source
            DC.W    0000               ; end of constant string

BaudTable   DC.W    1200,94,102        ; 1200 baud, Mac&LisaB , LisaA BRG
constants
            DC.W    2400,46,50         ; 2400 baud
            DC.W    4800,22,24         ; 4800 baud
            DC.W    9600,10,11         ; 9600 baud
```

(continued on next page)

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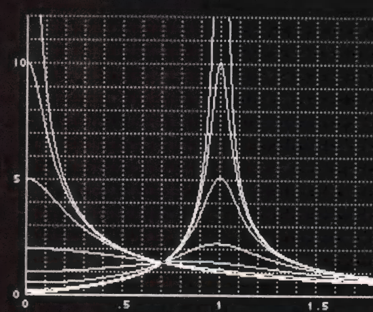

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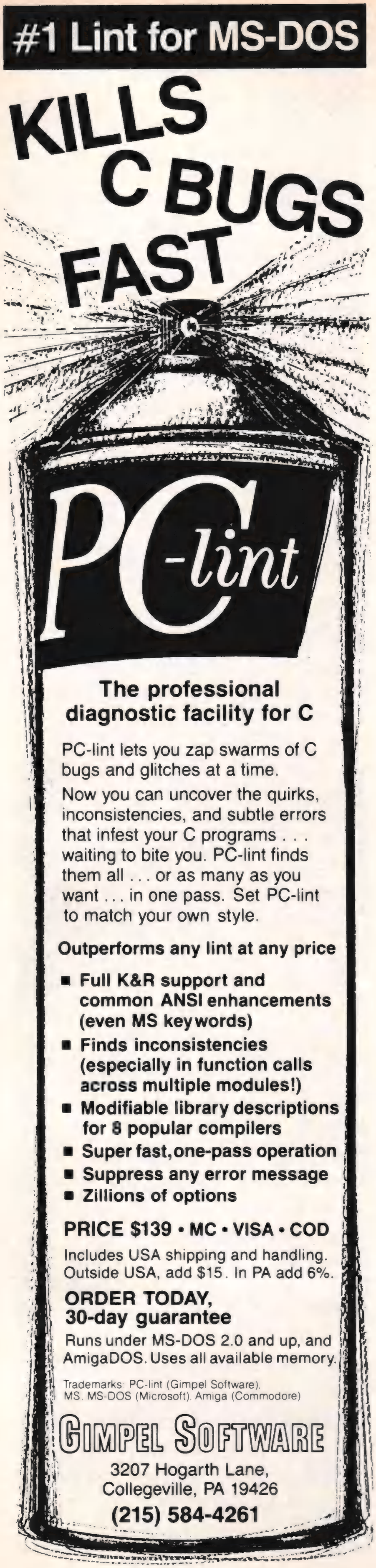

Listing One *(Listing continued, text begins on page 18.)*

```
            DC.W    19200,4,-1          ; 19200 baud (but not for Lisa Port
A...)
BaudTblEnd  DC.W    -1                  ; sentinel
;
MSetBaud    move    CSParam(a0),D0      ; get the (integer) baud rate
            bsr.s   Set_Baud
            bra     AbusExit

Set_Baud    _SUBR                       ; D0 contains the actual desired baud
rate
            move.w  D0,AALAPbaud(A2)    ; save the current baud rate
            lea     BaudTable,A0        ; point at the table
@10         cmp.w   (a0),D0             ; does it match?
            beq.s   @30                 ; go if so
            addq.l  #6,A0
            tst.w   (A0)                ; are we done?
            bpl.s   @10                 ; loop if we didn't hit the sentinel
            moveq   #-1,D0              ;
            bra.s   @50                 ; and bail out

@30         moveq   #3,D1               ; set up for Mac port A/B (PCLK/BRG on)
            CMPI.B  #$FF,MacTypeByte    ; Mac or Lisa?
            BNE.S   @40                 ; Branch if Mac (PortA & PortB are
same)
        IF  PortA THEN                  ; Lisa ports A/B differ; Macs don't
            addq.l  #2,A0               ; bump to Lisa PortA column
        ELSE
            moveq   #1,D1               ; Lisa portB works from Xtal, not PCLK
        ENDIF
@40         move.w  2(a0),D0            ; get value BRG (-1 if 19,200 on Lisa)
            bmi.s   @50                 ; exit if negative

; D0 now contains the value for the BRG
            lea     BaudConsts,a0       ; point at the constants
            move.b  d0,lsBaudVal-BaudConsts(a0) ; save the LSByte of the BRG
            ror     #8,d0
            move.b  d0,msBaudVal-BaudConsts(a0) ; and the MSByte of the BRG
            move.b  d1,BaudSrc-BaudConsts(a0)   ; and the source for BRG
            bsr     toSCC               ; and output it
            clr     d0
@50         _SUBEND 'MSETBAUD'
            EJECT
;_______________________________________________________
;
; MWriteLAP - write out a LAP packet
;
;   Call:
;       A0 -> IO queue element
;       A1 -> WDS. First entry must start as follows:
;                 +------------------+
;                 | Destination addr|
;                 +------------------+
;                 |                  |     [ for source addr ]
;                 +------------------+
;                 |  LAP type code   |
;                 +------------------+
;                 :                  :
;       A2 -> local variables
;
;   Return:
;       D0 = error code
;
; NOTE: for MPP, first two data bytes must be length
;_______________________________________________________

MWriteLAP   MOVE.L  2(A1),A0            ; A0 -> first WDS entry
            MOVEQ   #LAPProtErr,D0      ; Assume an error (2.3F)
            TST.B   LAPType(A0)         ; Make sure protocol is a valid one
            ble.s   MWRLAPex            ; Return error if not
            MOVE.B  LAPDstAdr(A0),D2    ; D2 = destination address
            bsr.s   LAPWrite            ; Write out the packet
MWRLAPex    bra     AbusExit
            EJECT
;_______________________________________________________________________
;
; LAPWrite - send a packet out an Async port.  Called both by MWriteLAP
; and DDPWrite.
;
;   Call:
;       A1 -> WDS (first entry must start as in MWriteLAP above)
;       A2 -> local variables
```

```
;        D2 = LAP destination address
;
;   Return:
;        D0 = noErr or the error code
;        Uses D1-D3,A0,A1,A3
;
; Save the WDS passed in
; If AALAP isn't up, return noAnswer
; Next, check the length of the frame for <= 603 bytes; return error if bad
; If we're currently sending a frame:
; if it's an IM/UR, simply return (WDS will be sent when done)
; if it's not, then stop (somehow we got two frames to send from DevMgr)
; If interrupts are on
;    Update PollProc pointer if it needs it
;    Check that the AALAP is still working, sending IM/UR if necessary.
; Start sending the frame
;
; This code relies on the Device Manager for queuing.  Here's how it works:
;
; General Rule #1: All operations initiated by the device manager
; ultimately return to the DevMgr through jIOdone.
;
; General Rule #2:  All async operations which cannot complete immediately
; return thru a RTS.  When the operation does complete, the (interrupt)
; routine can go thru jIOdone.
;
; Specific AppleTalk Rule #1:  All callers of LAPWrite have bra AbusExit
; code right after the call to LAPWrite.  This eventually jumps to jIOdone.
;
; Specific AppleTalk Rule #2:  Since they've taken care of the details,
; LAPWrite only has to remember two things: If we finish, we can return
; to our original caller (by jumping thru LAPWrtRtn to go to the device
; manager);  If we don't finish, we should return to the caller's caller
; (which called the device manager in the first place).  Whew!
;_____________________________________________________________________________

LAPWrite    move.l    (SP)+,LAPWrtRtn(A2) ; save the caller's adrs
            move.l    A1,WDSptr(A2)       ; and the frame we're asked to send

            move.w    #noAnswer,D0
            tst.b     AALAPup(a2)         ; is the AALAP up?
            beq       LAPWexit            ; exit if bad
;
; Next compute the length of the WDS -- exit if it's bad
;
            move.l  A1,A0                  ; get the WDS pointer

            clr.l   D2                    ; D2 = number of data bytes in frame
            clr.l   D1                    ; D1 = number of segments in WDS
            cmp.w   #2,(a0)               ; is first segment too short?
            ble.s   LAPWexit              ; go if it is
@20         tst.w    (a0)                 ; is WDS length = 0?
            beq.s   @30                   ; go if so
            add.w   (a0),d2               ; add in this length
            addq    #1,d1                 ; incr the segment counter
            addq.l  #6,A0                 ; bump the WDS pointer
            bra.s   @20

; D2 is the length of the message we've been asked to send
; D1 is the number of segments we've been presented with
; (A1 still has WDSptr)

@30         moveq   #LAPProtErr,D0
            tst.l   d1                    ; is D1 (number of segments) < 1?
            ble.s   LAPWexit              ; go if so (error)
            moveq   #ddpLenErr,D0
            cmp.w   #603,D2               ; is the length > 603 (3 LAP + 600
data)
            bgt.s   LAPWexit              ; go if it's bad
;
; we can try to send WDS in A1 -- are we currently sending a frame?
;
            tst.l   tWDSptr(a2)           ; are we presently sending a frame?
            beq.s   @40                   ; go if not
            tst.b   SendingIMUR(A2)       ; is it an IM or UR?
            beq.s   @35                   ; go if not
            tst.l   qWDSptr(A2)           ; is one already queued?
            bne.s   @35                   ; go if so (stop)
            move.l  A1,qWDSptr(A2)        ; save the (queued) WDS pointer
           _statcount DeferXmit
            rts
```

(continued on next page)

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CIRCLE 329 ON READER SERVICE CARD

Listing One *(Listing continued, text begins on page 18.)*

```
@35         pea      AALAP2in1            ; point at the string
            DC.W     $ABFF                ; and trap 'em (in lieu of $A9FF)

;
; WDS in A1 is OK to send now: if interrupts enabled,
;    update PollProc and check time since last good frame
;
@40         move     SR,D0
            and      #$70,D0              ; is the interrupt mask <> 0?
            bne.s    SendWDSptr           ; just send it
;
; Update our local PollProc pointer
;
            move     SR,-(A7)             ; save the state
            move     #SCCLockout,SR       ; turn off interrupts
            lea      myPollProc,A1        ; A1 -> our PollProc
            move.l   PollProc,D0          ; get the current PollProc address
            cmp.l    D0,A1                ; have we already updated it?
            beq.s    @50                  ; go if we have
            move.l   D0,SavePS(A2)        ; else update our saved copy
            move.l   A1,PollProc          ; and point the real PollProc at us
@50         move     (A7)+,SR             ; and re-enable
;
; check for (Ticks - LastRcv) > 1800 - see if they're still there
;
            move.l   Ticks,D0             ; have we received a frame recently?
            sub.l    LastRcv(a2),D0
            cmp.l    #1800,D0             ; (ticks - LastRcv) > 1800 (30 sec)?
            bmi.s    SendWDSptr           ; go if not (send it)
            bsr      Get_NNNN             ; do the IM/UR stuff
            beq.s    SendWDSptr           ; go if it worked
            move.w   D0,-(SP)             ; otherwise, save the status
            bsr      DoWarn               ; else, warn them
            move.w   (SP)+,D0             ; and return bad status
;
; Come here if we need to return immediately (status is in D0)
;
LAPWexit    move.l    LAPWrtRtn(A2),A0    ; this'll get 'em to IOdone
            jmp       (A0)                ; sooner or later

AALAP2in1        dc.b 24
            dc.b     'AALAP - TWO MSGS AT ONCE'
            align 2
            EJECT
;__________________________________________________________________
;
; SendFrame -- Starts off transmission of a frame
;
; A0 points to the WDS of the frame to send
;
; SendFrame sets all the pointers, etc.  and then sends the FrameChar
; ($A5).  The Transmit Interrupt Handler ships all the remaining bytes
; as they are needed.
;
;__________________________________________________________________

SendWDSptr  move.l   WDSptr(A2),A0        ; get the WDS to send
SendFrame   move.w   (a0)+,D0             ; D0 = the length of the 1st segment
            move.l   (a0)+,a1             ; a1 -> the first byte of 1st segment
            move.l   a0,tWDSPtr(a2)       ; and save the pointer to rest of WDS
            subq     #2,D0                ; Finagle the length and address
            move     D0,TxCount(a2)       ;   of the segment (AALAP doesn't
            addq.l   #2,A1                ;   send dest and source node)
            move.l   a1,LAPFetch(a2)      ;
            st       nCRC(a2)             ; we'll need to send a CRC
            st       nFrmChr(a2)          ;    and a closing FrmeChar
            sf       EscOut(a2)           ; clear the Escape flag
            clr      OutputCRC(a2)        ; and the CRC
            moveq    #qFrmChar,D0         ; load a FrameChar
            bra.s    SendSCC              ; and kick off the frame
           EJECT
;__________________________________________________________________
;
; LAPSend -- send the next byte in the LAP frame
;
; This routine checks to see if we're flow-controlled, if not, it
; gets the next char, accumulates the CRC, generates DLE's as
; required, and calls the routine to place the byte in the SCC.
;
; It works from LAPFetch(a2), and advances it (and decrements TxCount)
; as necessary.
```

(continued on page 74)

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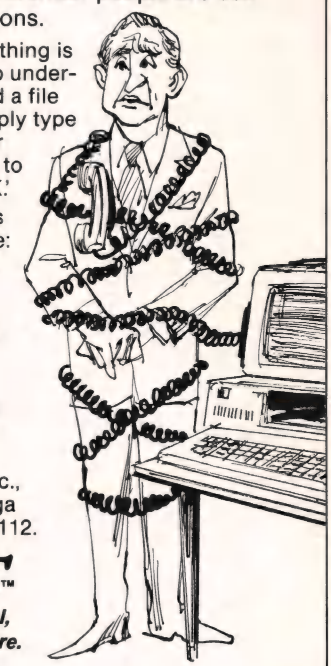

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CIRCLE 395 ON READER SERVICE CARD

Listing One *(Listing continued, text begins on page 18.)*

```
;
; If we sent a char, then we set SentChar(A2) to true
;_______________________________________________________________

LAPSend      tst.b    RcvdXoff(a2)          ; are we flow controlled?
             bne.s    LAPSendRTS            ; go if so

             move     TxCount(a2),D3        ; get the remaining length
             ble.s    LAPBadCount           ; go if zero or negative
             cmp.w    #maxLAPFrmLen,D3      ; check its length
             bgt.s    LAPBadCount           ; go if too big

             move.l   Ticks,LastXmit(a2)    ; remember when we last sent a char
             subq     #1,D3                 ; decr the count
             move.l   LAPFetch(a2),a0       ;
             move.b   (a0)+,D0              ; and fetch the character, bumping the ptr

             tst.b    EscOut(a2)            ; are we escaping this char?
             bne.s    @15                   ; go if yes -- it's already in CRC
             lea      OutputCRC(a2),a3      ; point at the output CRC Accumulator
             bsr      NextCRC               ; accumulate the un-processed char

             cmp.b    #DLE,D0               ; test for DLE, Xon, Xoff, FrameChar
             beq.s    @10                   ; go if it's a special one
             cmp.b    #FrameChar,D0
             beq.s    @10
             move.b   D0,D1
             and.b    #$7F,D1               ; is it a XON or XOFF (either parity)?
             cmp.b    #Xoff,D1
             beq.s    @10
             cmp.b    #Xon,D1
             bne.s    @20                   ; go if it's just a normal character

@10          st       EscOut(a2)            ; remember that we're escaping
             moveq    #DLE,D0               ; data to send is a DLE
             bra.s    SendSCC               ;  (and don't update the pointer/len)

@15          eor      #$40,D0               ; come here if we're escaping this char
@20          move.l   a0,LAPFetch(a2)       ; update the pointer
             move     D3,TxCount(a2)        ;    and the remaining length
             sf       EscOut(a2)            ;
;                                           ; D0 has the next char to send
;            bra.s    SendSCC               ; and send the character
;
; SendSCC -- sends D0 to the SCC Write Data Register
;            Assumes that SCC is ready (TBMT is true)
; Returns D0 = 0
; uses A1
;
SendSCC      st       SentChar(A2)          ; remember we sent a char
             move.l   SCCWr,a1              ; point at the SCC Write Control
             IF       PortA THEN
             addq.l   #ACtl,a1              ; add in the offset for Port A
             ENDIF
             move.b   D0,SCCData(a1)        ; output the character
             moveq    #0,D0                 ; clear the return status
LAPSendRTS   rts                            ; and return
LAPBadCount  pea      BadCntStr
             DC.W     $ABFF                 ; Trap 'em (not $A9FF)
             rts
BadCntStr          DC.B       10
             DC.B     'Bad length'
             align 2
             EJECT
;_______________________________________________________________
;
; SendChar -- Synchronously wait for TBMT and send another character
;       Use Ticks to watch for 1/2 sec timeout, so we don't hang forever
;
; Entry:          D0 = char to send
; Exit:           D0 = 0000 if OK
;                 D0 = BadTBMT if we timed out (-3110)
;                 A0,A1,D2 changed
;_______________________________________________________________

SendChar     _SUBR
             move     Ticks,D2              ; fail-safe counter
             add.l    #30,D2                ; bump by 1/2 second
@10          bsr.s    TestTBMT              ; look to see if we can send it
             bne.s    @20                   ; go if we can
             cmp.l    Ticks,D2              ; did we time out?
```

```
            bpl.s    @10                 ; go if not
            move     #-3110,D0           ; BadTBMT return code
            bra.s    @40

@20         bsr.s    SendSCC              ; else send it

@40         _SUBEND 'SENDCHAR'
;
; Check state of TBMT - sets CCR to state of TBMT
; Uses A0
;
TestTBMT     movem.l SCCRd,A0             ; point at the SCC
            IF       PortA THEN
            addq.l   #Actl,A0
            ENDIF
            btst     #TxEmptyBit,(a0)     ; is the TBMT set?
            rts                           ; return
            EJECT
;______________________________________________________________________
;
; TIntHnd -- this code catches the Tx Buffer Empty interrupts from
;       the SCC and tries to send another character.  If it could not
;       send a character, it clears the Tx Pending bit, so that the SCC
;       will not interrupt again.  Finally (in any case) it also resets
;       the highest interrupt under service (IUS) in the SCC to clear
;       the interrupt before returning.
;
; On entry, A0/A1 point to the SCC control read/write registers.
; Like a normal interrupt handler, it must preserve D4-D7 and A4-A7
;______________________________________________________________________

TIntHnd     move.l  MPPVars,a2           ; point at the MPP Variables
            _statcount XmitCount         ;

            sf      SentChar(A2)         ;
            bsr.s   TxNextCh             ; try to send another char

            tst.b   SentChar(A2)         ; did we?
            bne.s   TintIUS              ; go if so
            move.l  SCCWr,A1             ; otherwise reset TxPend
            IF      PortA THEN
            addq.l  #Actl,A1
            ENDIF
            move.b  #$28,(A1)
TIntIUS     bra     DoIUS                ; and reset the highest IUS

;______________________________________________________________________________
;
; TxNextCh -- try to send (in this order)
;           the next character of the segment, or
;           the next segment, or
;           the CRC, or
;           the trailing FrameChar.
;
; If a complete frame which was initiated by the device manager has
; been sent, we should jump thru IODone (asking the DevMgr for more
; to do).  Otherwise, (it was an IM or UR) we look to see if there
; is a frame from the DevMgr queued (in WDSptr).  If so, we start
; sending it, otherwise, we simply RTS.
;______________________________________________________________________________

TxNextCh    move.l  tWDSPtr(a2),D0       ; D0 -> WDS in progress
            beq.s   TxNextRTS            ; if nil, just exit (no message)
            tst.w   TxCount(A2)          ; is there more of the segment to send
            bne     LAPSend              ; if so, send next character

@5          move.l  D0,A0                ; otherwise, point at the WDS
            tst     (a0)                 ; check the next length
            beq.s   @10                  ; go if it's zero (end of the frame)
            move    (a0)+,TxCount(a2)    ; otherwise, update TxCount and
            move.l  (a0)+,LAPFetch(a2)   ;    and LAPFetch
            move.l  a0,tWDSptr(a2)       ; and update the tWDSPtr
            bra     LAPSend              ; and send it off
;
; Now send the CRC
;
@10         tst.b   nCRC(a2)             ; do we need to send a CRC?
            beq.s   @20                  ; go if not
            sf      nCRC(a2)             ; don't need one now
            move    outputCRC(a2),D0     ; get the two CRC bytes
            ror.w   #8,D0                ; swap them
```

(continued on next page)

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CIRCLE 388 ON READER SERVICE CARD

Listing One *(Listing continued, text begins on page 18.)*

```
            lea      CRCBuf(a2),a0       ; point at the CRC Tx Buffer
            move     D0,(a0)             ; save the CRC bytes
            move.l   a0,LAPFetch(a2)     ; and save the fetch pointer
            move     #2,TxCount(a2)      ; save the length, too
            bra      LAPSend             ; and send them off
;
; We've sent the CRC, now send the closing FrameChar
;
@20         tst.b    nFrmChr(a2)         ; do we need to send a FrameChar?
            beq.s    @30                 ; go if not
            sf       nFrmChr(a2)         ;
            moveq    #qFrmChar,D0        ; get $A5
            bra      SendSCC             ; send it and exit
;
; We've sent a full frame, now clean up
;
@30         clr.w    TxCount(a2)         ; clear the TxCount
            clr.l    tWDSPtr(a2)         ; clear the tWDSptr (no longer sending)
;
; Now decide whether to return, wakeup the Dev. Mgr, or start a queued frame
;
            tst.b    SendingIMUR(A2)     ; were we sending an IM or UR?
            beq.s    NotIMUR             ; go if not
            sf       SendingIMUR(A2)     ; well, we're not anymore
            move.l   qWDSptr(A2),D0      ; is there a queued frame?
            beq.s    TxNextRTS           ; go if not
            move.l   D0,A0
            bra      SendFrame           ; otherwise, start sending it
TxNextRTS   rts                          ; otherwise, return (RTS)
;
; We weren't sending IM/UR so we must have finished a msg from the
; device mgr.  Therefore, we should return to the Device Manager.
;
NotIMUR     clr.l    qWDSptr(A2)         ; clear out the WDS
            moveq    #0,D0               ; good return status
            bra      LAPWexit            ; and go thru LAPWrtRtn to IOdone
            EJECT
;________________________________________________________________________
;
; RandomWord - generate a random number
;
;   Call:
;       RandomSeed(A2) = seed
;
;   Return:
;       D0 = random number (CCR set to it)
;________________________________________________________________________

RandomWord  MOVE     RandomSeed(A2),D0   ; D0 = current seed
            MULU     #773,D0             ; Times 773
            ADDQ     #1,D0               ; Plus 1
            MOVE     D0,-(SP)            ; Save high byte on stack
            LSL      #8,D0               ; Put low byte into high byte
            MOVE.B   (SP)+,D0            ; And high byte into low byte
            MOVE     D0,RandomSeed(A2)   ; Set back in seed
            RTS
            EJECT
;______________________________________________________________________
;
; VBL handler - come here every VBLtimer ticks. Used to check for long
; output puases; if we stop for > 1 second, we expermientally send
; the next character.
;   A0 -> VBL queue element
;______________________________________________________________________

VBLHnd      MOVE     #VBLtimer,VBLCount(A0) ; Better re-init VBL count
            MOVE.L   MPPVars,A2             ; A2 -> local variables
;
; Have we sent an Xoff (did we set nXon)?  If so, try to send an Xon
;
            tst.b    nXon(A2)            ; do we need an Xon?
            beq.s    @20                 ; go if not
            bsr      TestTBMT            ; try to send it to the SCC
            beq.s    VBLHndRTS           ; quit if we couldn't send it
            moveq    #Xon,D0
            bsr      SendSCC             ; send an Xon
            sf       nXon(A2)            ; and clear the flag
            bra.s    VBLHndRTS           ; and quit
;
; Check for long pause during transmit
;
```

(continued on page 78)

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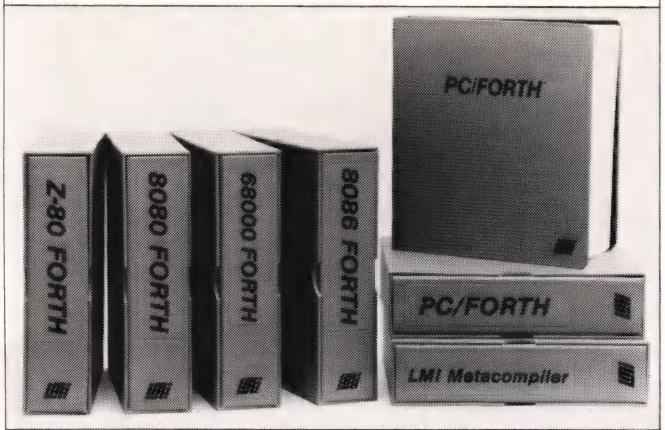

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Listing One *(Listing continued, text begins on page 18.)*

```
@20         tst.l   tWDSptr(A2)          ; do we have anything to send?
            beq.s   VBLHndRTS            ; return if not
            move.l  Ticks,D0
            sub.l   LastXmit(a2),D0      ; if (ticks - LastXmit) > 60 then
            cmp     #60,D0               ; let's try to send another char
            bmi.s   VBLHndRTS
            bsr     TestTBMT             ; is TBMT set (can we send another char?)
            beq.s   VBLHndRTS            ; go if not
            sf      RcvdXoff(a2)         ;
            _statcount XOFFTOcount
            MOVE    #SCCLockout,SR       ; exclude SCC interrupts (VIA priority < SCC)
            bsr     TxNextCh             ; otherwise, do another character
VBLHndRTS   rts                          ; this'll restore SR et al
            eject
;________________________________________________________________________
;
;   myPollProc -- AALAP PollProc addendum (predendum?):
;
;   The AALAP needs a bit of a PollProc, since it will lose characters
;   whenever the disk spins.  Of course, all good Macintosh programmers
;   know that the Printer Port (PortB) isn't polled by the disk driver
;   since there's just not enough horsepower to go around.
;
;   The PollProc is called by the disk driver to poll PortA.  We
;   execute a snippet of code before the real PollProc, and send an
;   Xoff to the other end if we're receiving or processing a message
;   while the disk is spinning.  Then we transfer to the real PollProc.
;
;   This routine preserves all regs except the SR.  It does this by
;   reserving a longword on the stack, and then stuffing the SavePS
;   value in it.  If it's zero, then there wasn't a PollProc, and we
;   pop that value off the stack and return to the disk driver.  If
;   that value wasn't zero, then the real PollProc's address will be
;   on the top of the stack, and we go there.  The disk driver's return
;   address will be left on the stack, allowing the PollProc to return
;   normally.
;
;   InpState and stillBusy must both be in the same word.  The
;   tst.w InpState(A2) below fails otherwise.
;________________________________________________________________________

myPollProc  subq    #4,A7                ; save space for a return adrs
            move.l  A2,-(SP)             ; and save A2
            move.l  MPPVars,A2           ; point at the MPP locals
            tst.b   nXon(A2)             ; have we already sent an Xoff?
            bne.s   myPPexit             ; go if so
            tst.w   InpState(A2)         ; are we receiving or processing a message?
            beq.s   myPPexit             ; go if not

            movem.l A0/A1/D0,-(SP)       ; save regs
@10         bsr     StashSCCch           ; grab a char from the SCC, save it
            bne.s   @10                  ; loop 'til it's empty
            statcount PPCount
            bsr     TestTBMT             ; is it OK to send the Xoff?
            beq.s   @30                  ; go if not
            moveq   #Xoff,D0
            bsr     SendSCC              ; send Xoff
            st      nXon(A2)             ; and remember we need Xon
            statcount PPXoffCnt
@30         movem.l  (SP)+,A0/A1/D0      ; restore the regs

myPPexit    move.l   SavePS(A2),4(SP)    ; move address onto stack (sets CC)
            movea.l (SP)+,A2             ; restore A2
            bne.s    @20                 ; go if PollProc adrs <> 0 (use it)
            addq.l   #4,SP               ; else pop the (nil) adrs
@20         rts                          ; and go there

            EJECT
;________________________________________________________________________
;
;  ExtIntHnd -- catch the External or Status Interrupts from the SCC
;
;  Checks for mouse interrupt, passes control if it is one, else resets
;  the external/status SCC interrupts.
;________________________________________________________________________

ExtIntHnd   btst    #DCDbit,D1           ; did the DCD bit change (mouse moved)
            beq.s   @10                  ; go if not
            move.l  MouseVector,A3       ; else, point at the mouse handler
            jmp     (A3)                 ; and go there
```

```
@10         move.b  #$10,(a1)              ; reset ext interrupts
            move.b  #$10,(a1)              ;     (twice)
            move.b  #ResetIUS,(a1)         ; Reset Highest IUS in SCC (to WR0)
            rts
            EJECT
;____________________________________________________________________________
;
; RIntHnd  - SCC receive interrupt handler
;
;   Called: A0 -> SCC control read register
;           A1 -> SCC control write register
;
; This code is structured differently from the ABLAP code, since
; the arrival rate of the chars is so much slower for AALAP.  Normal
; ABLAP routines call ReadPacket and ReadRest to get pieces or the rest
; of the frame as they arrive in real time.  With AALAP, the character
; arrival rate is so slow that we copy the entire frame into an
; interrupt-time buffer.
;
; When we receive a good frame, we then pass control to the appropriate
; protocol handler, which then makes calls on ReadPacket and ReadRest to
; dole out the characters as necessary.
;
; Like all Mac interrupt handlers, it must preserve D4-D7 and A4-A7.
; and return with a RTS instruction.
;
; Since the default DDP socket listener is quite slow (3-4 msec to process
; a newly received message) we set up a buffer to contain characters
; which arrive during the time the socket listener is in control.  We
; set a flag (stillBusy) to indicate that we're still busy, and save the
; chars in BusyBuf.
;____________________________________________________________________________

SpIntHnd
RIntHnd     move.l  MPPVars,A2             ; A2 -> driver variables
            _statcount RcvIntCount         ; remember the number of Rcv
interrupts

RIntHnd10   bsr     NextChar               ; handle next char (from BusyBuf or
SCC)
            beq     RIntRTS                ; quit if no data

            and     #$00FF,D0              ; use only eight bits
            move.w  D0,LastRxCh(a2)        ; remember the char
;
; Check for flow control from other side
;
@15         move.b  D0,D1                  ; check for either parity Xon/Xoff
            and.b   #$7F,D1
            cmp.b   #Xoff,D1               ; is it a control-S?
            bne.s   @20                    ; go if not
            _statcount XOFFcount           ; count it
            st      rcvdXoff(a2)           ; and remember we received Xoff
            bra.s   RIntHnd10              ; loop for another char

@20         cmp.b   #Xon,D1                ; or is it a control-Q?
            bne.s   @30                    ; go if not
            _statcount XONcount
            sf      rcvdXoff(a2)
            bsr     TestTBMT               ; is the tx empty?
            beq.s   RIntHnd10              ; loop if not
            bsr     TxNextCh               ; otherwise, start up Tx side again
            bra.s   RIntHnd10              ; loop for another char
;
; Watch out for framing characters
;
@30         cmp.b   #FrameChar,D0          ; is it a framing character?
            beq.s   GotFrmCh               ;     go if so
            tst.b   InpState(a2)           ; are we in a frame?
            beq.s   RintHnd10              ;     loop for another char
            EJECT
;
; Maybe this is a data char -- check the frame length
;
            cmp     #MaxLAPFrmLen,rcvdlen(a2) ; is the frame too long?
            bls.s   @50                    ; go if it's OK
            _statcount LongFrame           ; remember the long frame
            sf      InpState(a2)           ; go idle
            bra.s   RIntHnd10              ; loop for another char
;
; We have a real char -- un-escape it
```

(continued on next page)

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Listing One *(Listing continued, text begins on page 18.)*

```
;
@50         cmp.b   #DLE,D0             ; is it a DLE?
            bne.s   @90                 ; go if not
            st      EscIn(a2)           ; remember we've seen an escape
            bra.s   RIntHnd10
;
; This is a data char -- complete any escaping, accumulate the CRC
;
@90         tst.b   EscIn(a2)           ; should we escape it?
            beq.s   @100                ; go if not
            eor     #$40,D0             ; xor with $40
            sf      EscIn(a2)           ; and clear the escape flag

; now we've got a good char
@100        lea     inputCRC(a2),a3     ; point at the CRC accumulator
            bsr     NextCRC             ; update the CRC accum using byte in
D0
            move.l  LAPStash(a2),a0     ; point at the next free char in
buffer
            move.b  D0,(a0)+            ; save the char in the buffer, bump the
pointer
            addq    #1,rcvdlen(a2)      ; increment the bytes-read counter
            cmp     #3,rcvdlen(a2)      ; have we read in exactly three chars?
            bne.s   @110                ; go if not
            move.l  LAPInBuf(a2),a0     ; otherwise point at the LAPInBuf
@110        move.l  a0,LAPStash(a2)     ; and update the pointer
            bra     RIntHnd10           ; loop for another char

RIntRTS     bra     DoIUS               ; reset Highest IUS and return

;
; We've discovered a FrameChar -- check if we're done or just starting
;
GotFrmCh    tst.b   InpState(a2)        ; are we in a frame?
            beq.s   FrmStart            ;  go if not (we will be)

FrmEnd      cmp     #2,rcvdlen(a2)      ; found closing char
            bhi.s   CheckCRC            ;    go if frame is long enough
            _statcount ShortFrame       ; else, flag that we got a short frame
                                        ;    and fall into FrameStrt
;
; We're in a frame now!
;
FrmStart    lea     toRHA(a2),a3        ; a3 -> RHA (holds 1st 5 bytes)
            move.b  sysLAPAddr(a2),(a3)+ ; copy the node number
            move.b  sysABridge(a2),(a3)+ ; and the bridge address
            move.l  a3,LAPStash(a2)     ; remember where next byte goes
            st      InpState(a2)        ; change the InpState to in_msg
            sf      EscIn(a2)           ; and we're not escaping data
            clr     InputCRC(a2)        ; no CRC yet
            clr     rcvdlen(a2)         ; no data, either
            bra.s   RIntRTS
            EJECT
;
; We received a complete frame -- check the CRC
;
CheckCRC
            sf      InpState(a2)        ; we're not in a frame now
            tst     InputCRC(a2)        ; is the CRC zero?
            beq.s   LAPDemux            ; go if it is OK
            _statcount CRCCount         ; save the statistic
            bra.s   RIntRTS             ; and exit
;
; Come here on receipt of a good frame.  We've cleared the InpState
; to indicate we're out of a frame.
;

LAPDemux    _statcount FrmCount         ; log another good frame
            move.l  Ticks,LastRcv(a2)   ; remember this frame's arrival time
            lea     2+toRHA(a2),a3      ; a3 -> LAP type byte
            MOVE.B  (A3)+,D0            ; Get the LAPtype, bump pointer
            tst.b   D0
            BMI     LAPIn               ; If minus, it's a LAP packet

;
; Got a data packet - look for a protocol handler
;
            tst.b   AALAPup(a2)         ; but first, is the AALAP up?
            beq.s   @60                 ; go if it's not up
            MOVEQ   #(LAPTblSz-1),D2    ; D2 = index into active protocols list
@30         CMP.B   Protocols(A2,D2),D0 ; Match?
```

```
        DBEQ    D2,@30                ; (If none, D2 is negative - 3.1F)
        LSL.W   #2,D2                 ; Make D2 a longword index into Handlers
;
; Got a protocol handler -- Compute the desired length of the message in D1
;
        move.b  (a3)+,D1              ; Get MSByte of the length into D1
        and     #3,D1                 ; mask for two lsbits
        LSL     #8,D1                 ; Move to proper position
        MOVE.B  (a3)+,D1              ; D1 = total length
        move    rcvdlen(a2),D0        ; D0 = total chars received (DDP + LAP
+ CRC)
        subq    #3,D0                 ; disregard LAP type and CRC
        cmp     D1,D0                 ; are they equal?
        beq.s   @40                   ; go if so
        _statcount LenErrCnt          ; save the stats
        bra     RIntRTS               ; and exit

@40     SUBQ    #2,D1                 ; Subtract 2 for length bytes
        move    d1,RcvdLen(a2)        ; and remember the number of unread chars
        EJECT
;_______________________________________________________________________
;
;       At this point, Handlers(A2,D2) points to the address of the protocol
;       handler for this packet's protocol (or D2 is negative if there is
;       none -- 3.1F). JMP to it with the following:
;
;       A0,A1 = SCC read/write addressses
;       A2 = ptr to driver locals
;       A3 = ptr into the RHA (first 5 bytes loaded)
;       A4 will be the address of our read packet routine
;       A5 will be saved for handler's usage (until packet's all in or error)
;       D1 = length of packet still left to read (from header)
;
;       The protocol handler must obey the following conventions:
;
;       1) It must preserve, across the call, A0-A2, A4 and D1
;       2) A6 and D4-D7 must be saved and restored if used.
;       3) It must JSR to the routine at (A4) or 2(A4) with registers as defined
;          there, for the purpose of reading more of the packet and eventually
;          resetting the SCC for the next interrupt.
;_______________________________________________________________________

        TST     D2                    ; Is there a protocol handler? (3.1F)
        BMI.S   @60                   ; Branch if not
        bsr     DoIUS                 ; reset Highest IUS
        MOVEM.L A4/A5,SaveA45(A2)     ; Save A4 and A5 (may be free time now)
        move.l  LAPInBuf(a2),a4       ; point at the next char of the msg
        move.l  A4,LAPStash(a2)       ;    (we can snatch A4 for a few instrs)
        MOVE.L  Handlers(A2,D2),A5    ; A5 -> protocol handler
        LEA     ReadPacket,A4         ; A4 -> ReadPacket
        st      stillBusy(a2)         ; remember we're processing a frame
        move.w  VSCCEnable(A2),SR     ; re-enable so we can catch more chars (!)

        JSR     (A5)                  ; Call the protocol handler

        move.l  MPPVars,A2            ; point at our variables
        cmpa.l  SaveA45(A2),A4        ; paranoia land -- make sure they've left
        bne.s   @45                   ;    things as they should be
        cmpa.l  (SaveA45+4)(A2),A5
        beq.s   @50
@45     pea     BadA4A5
        DC.W    $ABFF                 ; print the text (in lieu of $A9FF)
@50     sf      stillBusy(A2)         ; and now we're not in a frame
        rts                           ; exit the interrupt handler
;
; No handler, just log the error
;
@60     _StatCount NoHandCnt          ; Count packets without a handler
        bra     RIntRTS               ; and exit
BadA4A5 DC.B    17                    ; debugging only
        DC.B    'AALAP - Bad A4/A5'
        align 2
        EJECT
;_______________________________________________________________________
;
;   NextChar -- Handle the next char
;
;   This routine does two things:  If we're awaiting a full message, then
;   it gets the next character.  That char may have arrived from the SCC,
;   or it may be a char left in the BusyBuf. (Chars in the BusyBuf take
;   precedence.)
```

(continued on next page)

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Listing One *(Listing continued, text begins on page 18.)*

```
;
;   If we're still processing the previous message (stillBusy set true),
;   then all characters which arrive will be placed in BusyBuf, and the
;   associated pointers updated.  (Note: myPollProc also inserts data
;   into the BusyBuf, but it doesn't set stillBusy.)
;
;   Uses    A0,A1,D0
;   Assumes A2 -> MPPVars
;
;   Returns Z if no character
;           NZ if char present (char is in 8 lsbits of D0)
;_______________________________________________________________________
NextChar    _SUBR
            tst.b   stillBusy(A2)       ; are we still processing the prev.
frame?
            bne.s   @30                 ; go if we are

            bsr.s   GetBusyChar         ; else, look for a char from BusyBuf
            bne.s   @50                 ; quit if we got one
            bsr.s   GetSCCchar          ; else check the SCC
            bra.s   @50                 ; and quit

@30         bsr.s   StashSCCch          ; stash a char from SCC into BusyBuf
            bne.s   @30                 ; go back and look for more

@50         _SUBEND 'NEXTCHAR'
            _assumeEq BusyStash,BusyBuf+16 ; otherwise cmpa.l A0,A1 (above)
fails

GetBusyChar _SUBR                       ; get a char from the BusyBuf
            move.l  BusyFetch(A2),D0    ; get the fetch pointer
            cmp.l   BusyStash(A2),D0    ; is it the same as the stash pointer
            bne.s   @10                 ; go if not (more chars to do)
            lea     BusyBuf(a2),a0      ; point at the busy buffer
            move.l  a0,BusyStash(A2)    ; and save it in the BusyStash
            move.l  a0,BusyFetch(A2)    ; and BusyFetch
            moveq   #0,D0               ; clear the CC
            bra.s   @20
@10         move.l  D0,A0               ; there's still more to take
```


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```
            move.b  (A0)+,D0            ; get the byte
            move.l  A0,BusyFetch(A2)    ; update the pointer
            or.w    #$100,D0            ; make CC <> Z (must preserve 8
lsbits)
@20         _SUBEND 'GETBUSYC'
            EJECT
;____________________________________________________________________________
;
; GetSCCchar and StashSCCch both are called by RintHnd and myPollProc
; BOTH ROUTINES MAY ONLY USE A0, A1, AND D0!!!!!  (A2 will -> MPPVars)
;
;   GetSCCchar looks at RCA on the proper channel, and returns the char
;   in D0 if there was one (with CC set <> Z); else it returns CC = Z.
;____________________________________________________________________________
GetSCCchar  movem.l SCCRd,A0/A1         ; forces A0/A1 to point at SCC
            IF      PortA THEN
            addq.l  #Actl,A0
            addq.l  #Actl,A1
            ENDIF
            btst    #RCAbit,(A0)        ; is there a char?
            beq.s   @20                 ; go if not
            move.b  #1,(a1)             ; point at the error bits from RR1
            nop
            move.b  (a0),D0             ; get them (Overrun,Framing) in D0
            and     #$70,D0             ; any error bits?
            beq.s   @10                 ; go if not
            move.b  #ResetErr,(a1)      ; else send Error Reset to WR0
            nop
            move.b  #1,(a1)             ; point at WR1
            nop
            move.b  #$13,(a1)           ; and set up for int on all rx chars
            nop
            _statcount OVRcount         ; count 'em
@10         move.b  SCCData(a0),D0      ; and get the data (EVEN IF ERROR!)
            or.w    #$100,D0            ; set the SR (to NZ -- there's a char)
@20         rts
;
;   StashSCCch -- take a char from SCC, save in BusyBuf if there's space
;    Return Z if no char or no space; NZ otherwise
;
StashSCCch  bsr.s   GetSCCchar          ; look for a char in the SCC
```

(continued on next page)

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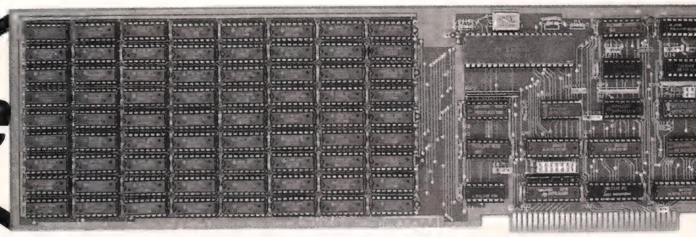

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CIRCLE 294 ON READER SERVICE CARD

Listing One *(Listing continued, text begins on page 18.)*

```
            beq.s    @50                    ; go if none
            lea      BusyStash(a2),A1       ; point at the BusyStash pointer
            move.l   (a1),A0                ; and get it
            cmpa.l   A0,A1                  ; will this be too many chars?
            beq.s    @50                    ; yes, simply exit (and ignore the char)
            move.b   D0,(a0)+               ; save the char, and bump the pointer
            move.l   A0,BusyStash(A2)       ; and update the pointer
            or.w     #$100,D0               ; set the CC <> Z ('cause we took one )
@50         rts                             ; and return
            EJECT
;_______________________________________________________________
;
; DoIUS  -- reset Highest IUS
;_______________________________________________________________

DoIUS       _SUBR
            move.l   SCCWr,A1               ; point at the SCC write regs
            IF       PortA THEN
            addq.l   #Actl,A1
            ENDIF
            move.b   #ResetIUS,(a1)         ; Reset Highest IUS in SCC (to WR0)
            _SUBEND  'DOIUS   '
            EJECT
;_______________________________________________________________
;
; LAPIn - it's a LAP control packet.
;
;    D0 = LAP type
;    A3 -> remainder of the frame
;    Note:  for IM/UR frames, the net number (2 bytes) is at (a3),
;           but the node number (1 byte) is the first byte in LAPInBuf
;_______________________________________________________________
;
; Check for IM
;
LAPIn       move     (a3),D1                ; D1 = Net number (a3 sb even)
            move.l   LAPInBuf(a2),A0        ; point at first char in input buf
            move.b   (a0),D2                ; D2 = node number
            cmp.b    #lapIM,D0              ; is it an IM?
            bne.s    @60                    ; go if not
            move     D2,D0                  ; D0 = node number
            sf       RcvdXoff(A2)           ; so we can start sending
            bsr.s    CheckIM                ; figure out the net and node to send
            bsr.s    SendIMUR               ; send 'em
            bra.s    @80
;
; Check for UR
;
@60         cmp.b    #lapUR,D0              ; is it a UR?
            bne.s    @80                    ; go if not
            move     D2,D0                  ; D0 = Node number (D1 = Net number)
            bsr.s    CheckUR                ; check these values, return <> 0 if OK
            sne      AALAPup(a2)            ; if non-zero, then we're up
@80         rts                             ; and return

            _AssumeEq    lapENQ,$81         ; (1)
            _AssumeEq    lapRTS,lapENQ+3    ; (2)
            _AssumeEq    lapCTS,lapRTS+1    ; (3)
            EJECT
;_______________________________________________________________
;
; CheckIM -- check the received IM frame, compute UR response
;
; Entry:  D0 = their node number
;         D1 = their network number
; Exit:   D0,D1 = node, net number for the UR
;         D2 = qlapUR
;         Changes A0,A1,A3, D0-D3
;_______________________________________________________________

CheckIM     move.l   #0,A0                  ; return nil sometimes
            move.w   SysNetNum(a2),D2       ; D2 = our Net number
            beq.s    @10                    ; go if so -- check the node numbers
            move     D2,D1                  ; else, use our net number
@10         move.b   SysLAPAddr(a2),D3      ; D3 = our node number
@15         tst.b    D0                     ; while (theirnode <> 0)
            beq.s    @18                    ; &      (theirnode <> mynode)
            cmp.b    D3,D0                  ; have we both chosen the same value?
            bne.s    @20                    ; go if not -- return their value
@18         bsr      RandomWord             ; choose a random value
            and      #$7F,D0                ; mask to 7 bits
```

(continued on page 86)

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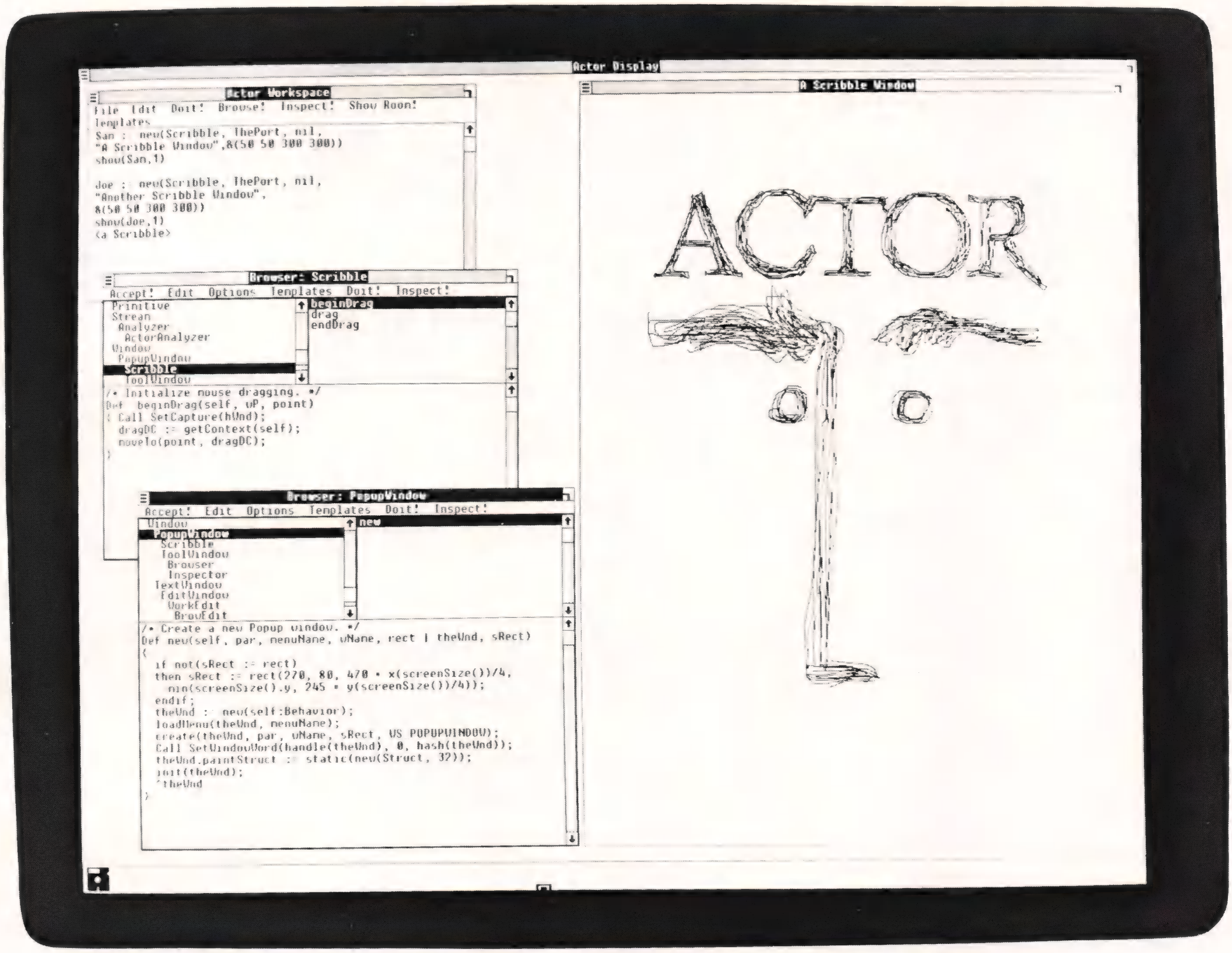

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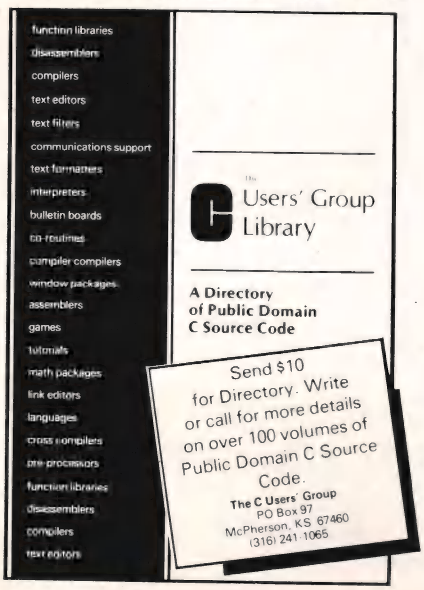

CIRCLE 181 ON READER SERVICE CARD

ASYNC APPLETALK

Listing One *(Listing continued, text begins on page 18.)*

```
            bra.s     @15                   ; loop to insure they're different
@20         move.b    D0,sysABridge(a2)     ; remember their node number
            moveq     #qlapUR,D2            ; D2 = LAP type
            rts

            EJECT
;_______________________________________________________________________
;
; CheckUR -- check the received UR frame
;
; Entry:  D0 = node number
;         D1 = network number
; Exit:   D0 =  0 if net/node didn't match
;            <> 0 if they matched right off
;
;
;_______________________________________________________________________

CheckUR     SUBR
            cmp       SysNetNum(a2),D1      ; Network numbers match?
            bne.s     @10                   ; go if not
            cmp.b     SysLAPAddr(a2),D0     ; Node number match?
            bne.s     @10                   ; go if not
            moveq     #-1,D0                ; make D0 non-zero (it's OK)
            bra.s     CkURRTS               ; and exit
@10         tst       SysNetNum(a2)         ; is our network number 0000?
            bne.s     @50                   ; go if not (we cannot resolve this)
            move      D1,SysNetNum(a2)      ; save their Net/Node suggestions
            move.b    D0,SysLAPAddr(a2)
            bra.s     @60

@50         st        AALAPstuck(a2)        ; we're really bad off -- NNNN conflict
@60         clr       D0                    ; we didn't match

CkURRTS     _SUBEND 'CHECKUR '
            EJECT
;_________________________________________________________________
;
; SendIMUR - This routine fills and sends an IM or UR frame.  This is
;    a bit dicey, since a UR may be required as a result of receiving
;    an IM.  Since it's difficult to abort a frame already in progress,
;    we finesse the problem by not sending the IM/UR frame.  Here's why
;    it works:
;
;    A UR response is only necessary in two cases:
;      a) we're trying to bring the link up, and the other guy said "IM";
;      b) he hasn't heard from us, and he wants to make sure we're here.
;
;    For a), we shouldn't be talking, but he'll ask again anyway;
;    for b), the IM is trying to force us to send a good frame.
;            If the frame in transit makes it, OK.  If not, he'll
;            still ask again.
;
; Entry:     A0 -> master pointer of this hdlblk
;            A2 -> MPPVars
;            D0 = node number
;            D1 = Net number
;            D2 = LAP type
; Exit:      A0,A1,A3,D0-D3 changed
;_______________________________________________________________________

SendIMUR    _SUBR
            tst.l     tWDSptr(A2)           ; are we sending?
            bne.s     SndIMUR1              ; yes, just return
            lea       IMURbuf+1(A2),A1      ; A1 points at IMURbuf (odd adrs)
            move.b    D2,2(a1)              ; save the LAPtype (IM or UR)
            move.w    D1,3(a1)              ; and the Net number
            move.b    D0,5(a1)              ; and the Node number

            lea       IMURwds(A2),A0        ; A0 points at the WDS
            move.w    #6,(A0)               ; save the length
            move.l    A1,2(A0)              ; and the pointer to the data
            clr.w     6(A0)                 ;

            st        SendingIMUR(A2)       ; remember this!
            bsr       SendFrame             ; and send it
SndIMUR1    _SUBEND 'SENDIMUR'
            EJECT
;_______________________________________________________________________
;
;   ReadPacket - read in the specified number of bytes into the specified
;        buffer. It is an error to request more bytes than have been received.
```

(continued on page 88)

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CIRCLE 227 ON READER SERVICE CARD

Listing One *(Listing continued, text begins on page 18.)*

```
;
;   ReadRest - read in the rest of the packet, putting the specified number
;       of bytes into the specified buffer.  Error if packet longer than buffer.
;
;   Call:
;       A0,A1,A2 = SCC read and write addresses and local variables
;       A3 -> buffer to read into
;       A4 -> start of ReadPacket
;       D3 = byte count to read (word)
;
;   Return:
;       D0 changed
;       D1 number of chars still unread (ReadPacket); modified (ReadRest)
;       D2 saved
;       D3  = 0 if exact number of bytes requested were read
;           > 0 indicates number of bytes requested but not read
;               (packet smaller than requested maximum)
;           < 0 indicates number of extra bytes read but not returned
;               (packet larger than requested maximum)
;       A0,A1 preserved by ReadPacket, modified by ReadRest
;       A3 -> one past where last character went
;       A4,A5 saved (until packet's all in or error)
;
; NOTE: CRC bytes not included in counts
---------------------------------------------------------------------

ReadPacket  BRA.S    DoRP                  ; Need this for two entry points

ReadRest    movem.l  a0/a1/D2,-(sp)        ; save some regs
            move     RcvdLen(a2),D1        ; get the number of remaining chars in D1
            move     D1,D0                 ; we expect to copy D1 bytes
            move     #0,-(sp)              ; and expect good return status
            sub      D1,D3                 ; compute (D3 - D1)
            bpl.s    @1                    ; go if we should copy D1 bytes (it fits)
            add      D3,D0                 ; otherwise, copy D3 bytes (d1 + (d3-d1))
            move     #-1,(sp)              ; and set error return status
@1          movem.l  SaveA45(a2),a4/a5     ; restore A4 and A5
            bra.s    DoCopy                ; and go to the common code
```

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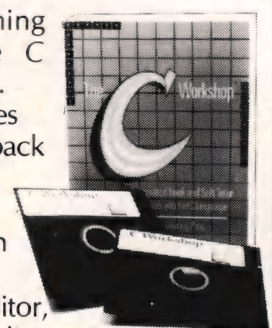

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```
DoRP      movem.l a0/a1/D2,-(sp)      ; push some regs
          move    RcvdLen(a2),D1      ; get the number of remaining chars in D1
          move    D1,D0               ; assume we'll copy them all
          move    #-1,-(sp)           ; and that there's an error
          sub     D3,D1               ; update D1 (remaining bytes in buf)
          bmi.s   DoCopy              ; go if it's negative (error)
          move    D3,D0               ; we'll read what they asked for (D3)
          clr     (sp)                ;  and remember that it's exactly right
          clr     D3                  ;

DoCopy    move.l  LAPStash(A2),a0     ; point at the source data
          ext.l   D0                  ; belt and suspenders (D0 = actual length)
          add.l   D0,LAPStash(A2)     ;    and update the LAPStash value
          sub     D0,RcvdLen(a2)      ;    and the num chars remaining
          move.l  A3,A1               ; point at the dest buffer
          lea     0(A3,D0),A3         ; update the return pointer
          _BlockMove                  ; Do It
          move    RcvdLen(a2),D1      ; return number of unread chars
          move    (sp)+,d0            ; get the return status back
          movem.l (sp)+,a0/a1/D2      ; get the other registers
          tst     D0                  ; set the CCR.
          rts
          EJECT

;______________________________________________________________________
;
; NextCRC -- compute a CRC on the word pointed at by A3 and the char in D0
;
;       This routine computes a CRC-16 on a stream of bytes.  It uses a
;       table lookup scheme to implement a x^16 + x^15 + x^2 + 1 polynomial.
;       The interested reader is referred to McNamara's Technical Aspects
;       of Data Communications, second edition, pps 110-122 for an obliquely
;       related discussion.
;
;       This routine takes the storage short cut of looking up two four-bit
;       values in a 16-entry table instead of one eight-bit value in a 256
;       word table.  This saves a considerable amount of space (32 bytes vs.
;       512 bytes for the table).
;
;       One pass thru this routine (one character) is about 262 cycles, or
;       33.45 usec on a Mac.  This is a data rate of ~29,900 char/sec,
;       or plenty fast to keep up with a 9600 baud link.
;
; Entry:  A3 -> CRC accumulator
;         D0    LSbyte is the data char (already masked to 8 bits)
;
; Exit:   D1,D2 changed
;         Other regs unchanged

;______________________________________________________________________

NextCRC _SUBR        0              ; for macsbug
        move         (a3),D2        ; D2 is the temp accumulator
        move         D0,D1          ; make a copy of the input character
; first work on the least significant nibble
        eor          D2,D1          ; xor the accumulator with the data char
        and          #$0F,D1        ;     to get an index into the CRCTable
        add          D1,D1          ; to make a word index
        lsr          #4,D2          ; shift the CRC right four bits
        move         CRCTable(D1),D1
        eor          D1,D2          ; and mask it with the approp. table entry
        move         D0,D1
        lsr          #4,D1          ; shift the data char right four bits
;  and do it again for the high nibble
        eor          D2,D1          ; xor the accumulator with the data char
        and          #$0F,D1        ;     to get an index into the CRCTable
        add          D1,D1          ; to make a word index
        lsr          #4,D2          ; shift the CRC right four bits
        move         CRCTable(D1),D1 ; and mask it with the approp. table entry
        eor          D1,D2
        move         D2,(a3)        ; remember this CRC for next time
        _SUBEND      'NEXTCRC '

CRCTable DC.W        $0000,$CC01,$D801,$1400
         DC.W        $F001,$3C00,$2800,$E401
         DC.W        $A001,$6C00,$7800,$B401
         DC.W        $5000,$9C01,$8801,$4400
            EJECT
;
. . .
```

(Listing One to be continued next month. Listings Two and Three will also appear next month.)

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CIRCLE 258 ON READER SERVICE CARD

FORTH PRELUDE

Listing One *(Text begins on page 40.)*

```
Listing 1

SCR# 0
( A Forth Standard Prelude )

This file defines additional functions and extensions which
cannot be provided in the Forth-83 Standard.

Select the appropriate prelude for the particular Forth you are
using and load it before loading a Standard program using these
functions.


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SCR# 1
( Select a FORTH-83 implementation)
FORTH DECIMAL

(     2 LOAD  ( *** model ****)
(   3 4 THRU  ( Lab Microsystems, Inc.  PC/FORTH  Ver. 3.0)
(     5 LOAD  ( Laxen-Perry                    F83  Ver. 2.1)
(     6 LOAD  ( MicroMotion MasterForth              Ver. 1.2)
(     7 LOAD  ( ZEN                                  Ver. 0.0)
(     8 LOAD  ( FORTH, Inc. PolyFORTH II     ISD-4  MS-DOS)

SCR# 2
( FORTH-83 functions-- typical definitions)
( Note: functions already provided need not be redefined.)
: RECURSE    [COMPILE] RECURSE ;  IMMEDIATE
: INTERPRET   INTERPRET ;

: I> ( - 'data )   COMPILE R> ;  IMMEDIATE
: >I ( - 'data )   COMPILE >R ;  IMMEDIATE

( Used for alignment: )
: ALIGN    HERE 1 AND ALLOT ;
: REALIGN  ( a - a' )   DUP  1 AND + ;

( Note: defined here for a dumb terminal.)
: TAB ( x y )   CR  2DROP ;
: PAGE   25 0 DO  CR  LOOP  0 0 TAB ;
: MARK ( a n)   TYPE ;

SCR# 3
( Lab Microsystems, Inc.  PC/FORTH  Ver. 3.0)

( RECURSE and INTERPRET are provided.)

( Used by hi-level run-time words to find in-line data: )
: I> ( - 'data )   COMPILE R> ;  IMMEDIATE
: >I ( - 'data )   COMPILE >R ;  IMMEDIATE

( PC/FORTH already has a word ALIGN which works differently.)
( The following two definitions must be in the order shown: )

: REALIGN  ( addr --- addr' )   ALIGN ;
( 8086/80286  run-time I realignment.)
: ALIGN  ( --)  EVEN ;
( 8086/80286  compilation address alignment.)


SCR# 4
( Lab Microsystems, Inc.  PC/FORTH  Ver. 3.0)

( x y --- )
: TAB   GOTOXY ;

( --- ; clear screen and home cursor )
: PAGE  CLS ;

( a n --- ; display string in inverse video )
: MARK   REVERSE TYPE  REVERSE ;



SCR# 5
( Laxen-Perry No Visible Support  F83  Ver. 2.1)
( RECURSE and INTERPRET are provided.)

( Used by hi-level run-time words to find in-line data: )
: I> ( - 'data )   COMPILE R> ;  IMMEDIATE
: >I ( - 'data )   COMPILE >R ;  IMMEDIATE

( Used for alignment: )
: ALIGN     ;    : REALIGN   ;

: PAGE  ( -- )         DARK ;
\ clear screen and home cursor.
: TAB    ( x y -- )   AT ;
\ move cursor to given coordinate.
: MARK  ( a n -- )    TYPE ;
\ the MARK function is not provided in F83.

SCR# 6
( MicroMotion MasterForth  Ver. 1.2.4)
( RECURSE is provided.)

: INTERPRET   TIB #TIB @ EVAL ;

: >I   COMPILE >R ;  IMMEDIATE
: I>   COMPILE R> ;  IMMEDIATE

NEED   ALIGN \IF  :   ALIGN ;
NEED REALIGN \IF  : REALIGN ;

( PAGE is provided.)
```

```
: TAB  ( x y)   AT ;
: MARK ( a n)  +INVERSE TYPE  -INVERSE ;


SCR# 7
( ZEN 0.0)

( RECURSE and INTERPRET are provided.)
( >I and I> are provided.)

NEED   ALIGN \IF  :   ALIGN ;
NEED REALIGN \IF  : REALIGN ;

( PAGE TAB and MARK are provided.)


SCR# 8
( FORTH, Inc. polyFORTH MS-DOS ISD)    HEX  1F1F WIDTH !
( Forth-83 Compatibility layer must be loaded first.)

: RECURSE   LAST @ @  2+  COUNT +  , ;  IMMEDIATE
( INTERPRET is provided.)

( Used by hi-level run-time words to find in-line data: )
: I> ( - 'data )   COMPILE R> ;  IMMEDIATE
: >I ( - 'data )   COMPILE >R ;  IMMEDIATE

( Used for alignment: )
: ALIGN     ;     : REALIGN    ;

( PAGE and MARK are provided.)
: TAB ( x y )    SWAP TAB ;
( move cursor to given coordinate.)
```

End Listing

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CIRCLE 315 ON READER SERVICE CARD

Listing One *(Text begins on page 46.)*

```
/*
 *
 *                              FINDCMD
 *
 *                           MODULE: MAIN.C
 *
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 *                        All Rights Reserved.
 *
 */

/*
 *      This module contains the driving loop of the program.
 */
#include        <stdio.h>

#include        "findcmd.h"

struct  attribs atts[] = {              /* For display */
        DIRECT, 'd',
        RDONLY, 'r',
        HIDDEN, 'h',
        SYSTEM, 's',
        ARCHIV, 'a'
};

char *month[] = {
        "Jan", "Feb", "Mar",
        "Apr", "May", "Jun",
        "Jul", "Aug", "Sep",
        "Oct", "Nov", "Dec"
};

main( ac, av )
int     ac;
char    *av[];
{
        int     i, len;
        char    dir[ MAXPATH ];
        char    path[ MAXPATH ];
        char    *tptr, tpath[ MAXPATH ];
        struct  dirent  dfile;

        if( ac == 1 ){
                fprintf( stderr, "usage: fc pat1 pat2 ... patn\n" );
                exit( 1 );
        }

        printf( "FINDCMD - COPYRIGHT (C) 1987, Charles F. Bowman. " );
        printf( "All Rights Reserved.\n\n" );

        sprintf( path, ".;%s", getenv("PATH") );        /* Get path */

        for( i = 1; i < ac; i++ ){
                /*
                 *      For each supplied pattern argument
                 */
                strcpy( tpath, path );
                tptr = tpath;
                inits( av[i] );         /* set-up transition table */
                while( (len = nextdir(tptr)) > 0 ){
                        /*
                         *      For each directory component
                         */
                        tptr[ len ] = NIL;
                        if( tptr[len-1] == '\\' ){
                                /*
                                 *      No double backslashes!
                                 */
                                sprintf( dir, "%s*.*", tptr );
```

```
                        } else {
                                sprintf( dir, "%s\\*.*", tptr );
                        }

                        /*
                         *      Compare each entry in directory
                         */
                        if( firstf(dir, &dfile) ){      /* Get first */
                                /*
                                 *      Error - bad dir in path
                                 */
                                fprintf( stderr,
                                        "BAD DIRECTORY SEGMENT: [%s]\n",
                                        dir );
                                break;
                        }
                        do{
                                if( state(slcase(dfile.dname)) ){
                                        /*
                                         *      Print if a match is found!
                                         */
                                        putfile( &dfile, tptr );
                                }
                        } while( nextf(&dfile) );       /* Get next */

                        tptr += len + 1;
                }
        }

        exit( 0 );
}

/*
 *      NEXTDIR: return the next directory component of 'PATH'
 */
nextdir( cp )
char    *cp;
{
        register        count;


        count = 0;
        if( *cp == NIL ){                       /* End of list */
                return( -1 );
        }
        while( *cp != NIL && *cp != FLDSEP ){
                cp++;
                count++;
        }
        return( count );
}

/*
 *      SLCASE: convert a string to lower case
 */
char    *
slcase( cp )
char    *cp;
{
        register char   *ptr;

        ptr = cp;
        while( *ptr ){
                *ptr = tolower( *ptr );
                ptr++;
        }

        return( cp );
}

/*
 *      PUTFILE: display directory info for each matched file
```

(continued on next page)

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CIRCLE 255 ON READER SERVICE CARD

Listing One

(Listing continued, text begins on page 46.)

```
 */
putfile( dfile, dir )
struct  dirent  *dfile;
char    *dir;
{
        int     i;
        char    datestr[ 50 ];

        /*
         *      Print attribute chatacters
         */
        for( i = 0; i < SA_SIZE(atts); i++ ){
                if( atts[i].val & dfile->dattr ){
                        putchar( atts[i].chr );
                } else {
                        putchar( '-' );
                }
        }

        fdosdte( datestr, &dfile->ddate );
                        /* DOS -> ASCII */
        if( dir[strlen(dir)-1] == '\\' ){
                /*
                 *      No double backslashes!
                 */

                printf( " %8D %s %s%s\n",
                        dfile->dsize,
                        datestr,
                        slcase(dir),
                        dfile->dname
                );
        } else {
                printf( " %8D %s %s\\%s\n",
                        dfile->dsize,
                        datestr,
                        slcase(dir),
                        dfile->dname
                );
        }

        return( 0 );
}

/*
 *      FDOSDATE: convert a DOS format date to an
                                        ASCII string
 */
fdosdte( where, dptr )
char    *where;
struct  dosdate *dptr;
{
        sprintf( where, "%s %2d %02d:%02d:%02d %4d",
                month[ dptr->month-1 ],
                dptr->day,
                dptr->hour,
                dptr->min,
                dptr->sec * 2,
                dptr->year + 1980
        );

        return( 0 );
}
```

End Listing One

Listing Two

```
/*
 *
 *                              FINDCMD
 *
 *                          MODULE: DOS.C
```

(continued on page 96)

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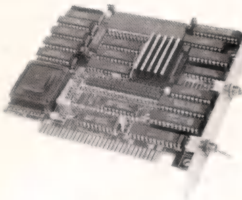

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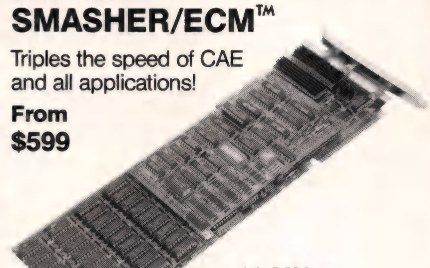

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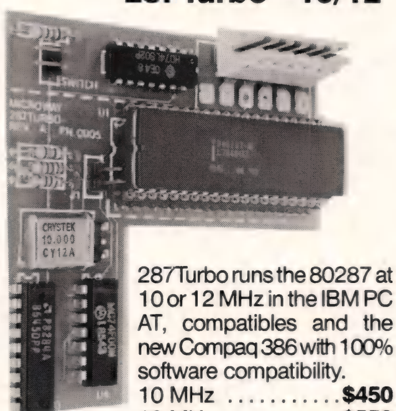

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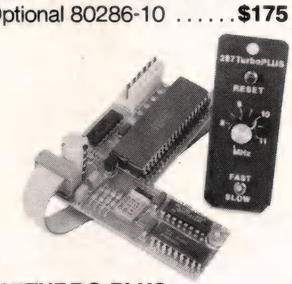

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Listing Two *(Listing continued, text begins on page 46.)*

```
 *
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 *                      All Rights Reserved.
 *
 */

/*
 *      This module contains the DOS dependent functions to
 *      access file names in directories. This is non-portable code.
 */
#include        <dos.h>
#include        <stdio.h>

#include        "findcmd.h"

struct  reg     regs;                   /* set & retrieve regs */
static  struct  dirent  lfile;          /* DOS disk trans addr */

/*
 *      FIRSTF: initiate DOS environment and return first file name
 */
firstf( dirpath, dfile )
char    *dirpath;
struct  dirent  *dfile;
{
        /*
         *      Set disk transfer address
         */
        regs.r_ax = SETDTA;
        ptoreg( dsreg, regs.r_dx, regs.r_ds, &lfile );
        intcall( &regs, &regs, DOSINT );

        /*
         *      Find first
         */
        regs.r_ax = NFFIRST;
        regs.r_cx = HIDDEN | SYSTEM | DIRECT | RDONLY | ARCHIV; /* All! */
        ptoreg( dsreg, regs.r_dx, regs.r_ds, dirpath );
        intcall( &regs, &regs, DOSINT );

        if( regs.r_flags & F_CF ){
                /*
                 *      Error!
                 */
                return( 1 );
        }

        *dfile = lfile;
        return( 0 );
}

/*
 *      NEXTF: return all subsequent files in directory
 */
nextf( dfile )
struct  dirent  *dfile;
{
        /*
         *      Call DOS: find next
         */
        regs.r_ax = NFNEXT;
        regs.r_cx = HIDDEN | SYSTEM | DIRECT | RDONLY | ARCHIV;
        intcall( &regs, &regs, DOSINT );
        if( regs.r_flags & F_CF ){
                /*
                 *      Error!
                 */
                return( 0 );
        }

        *dfile = lfile;
        return( 1 );
}
```
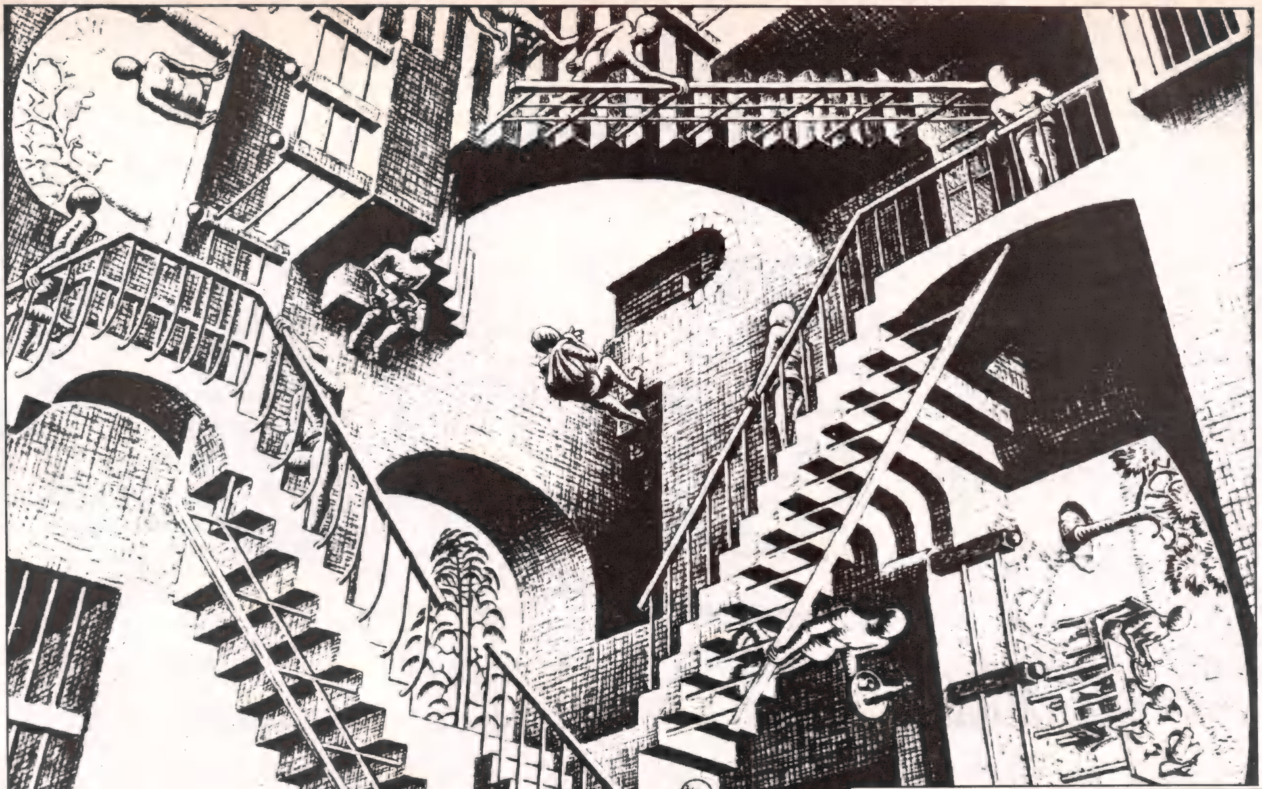

End Listing Two

(Listing Three begins on page 106.)



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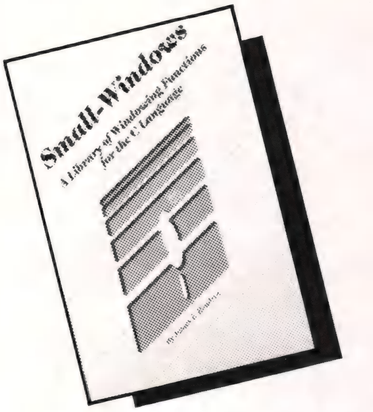

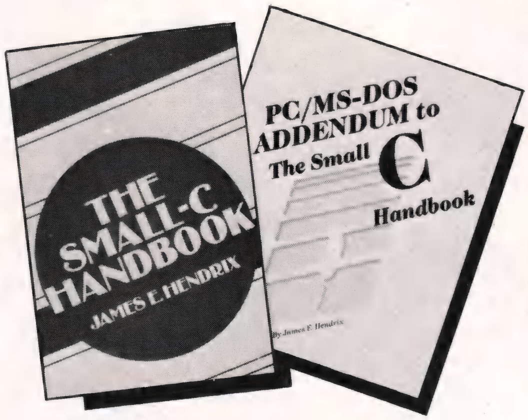

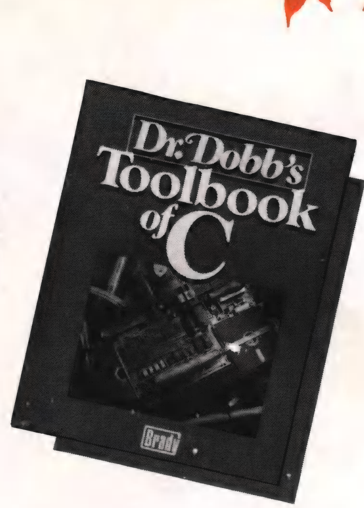

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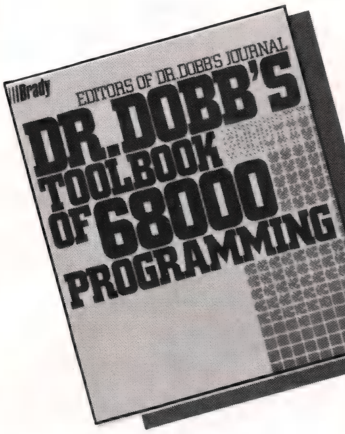

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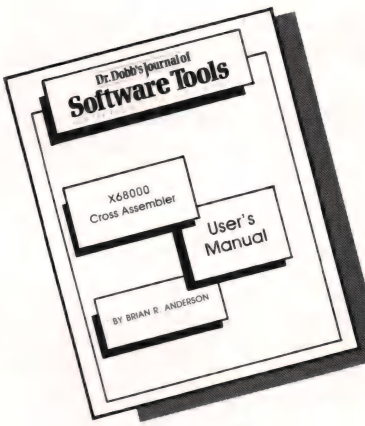

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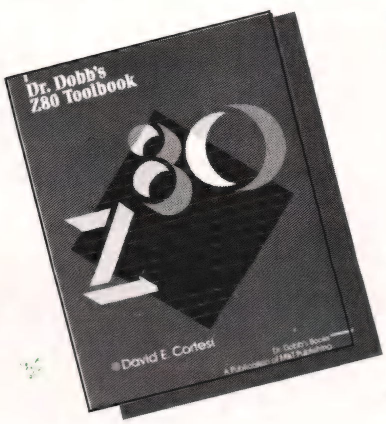

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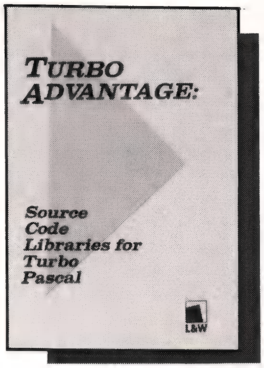

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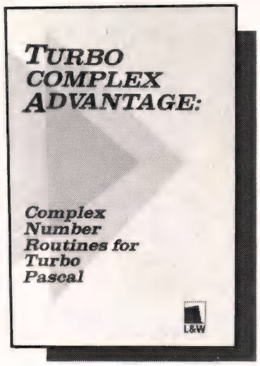

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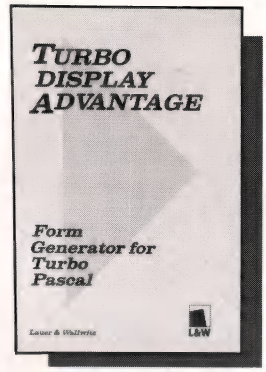

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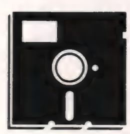

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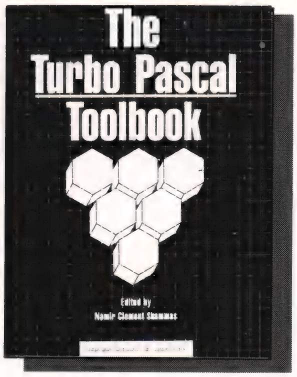

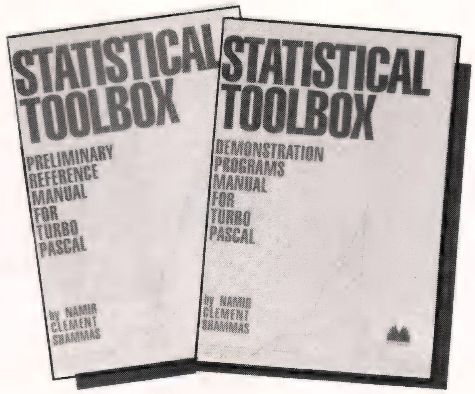

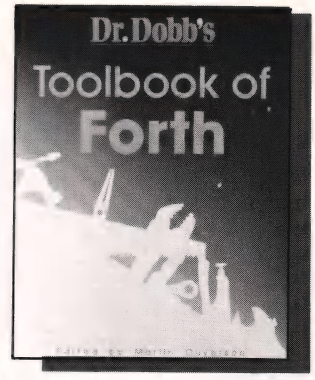

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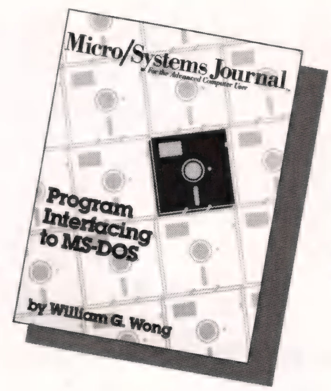

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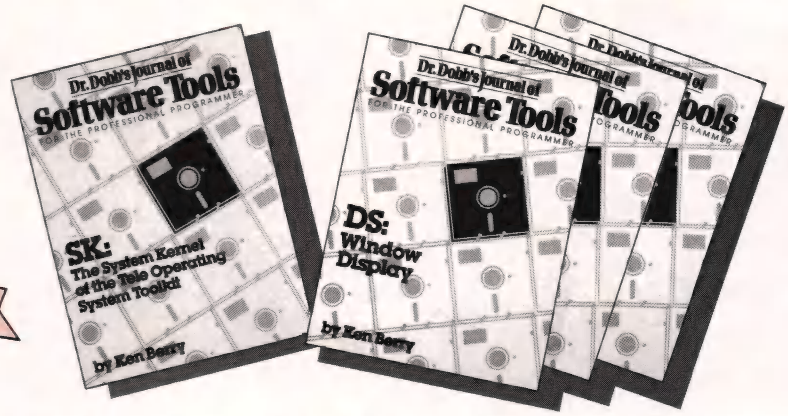

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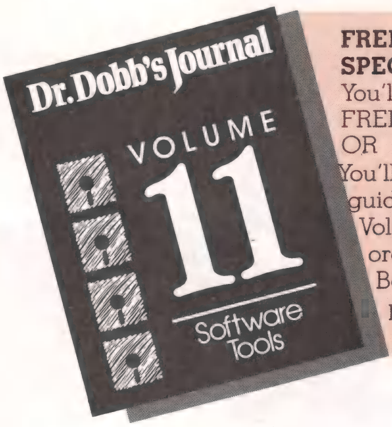

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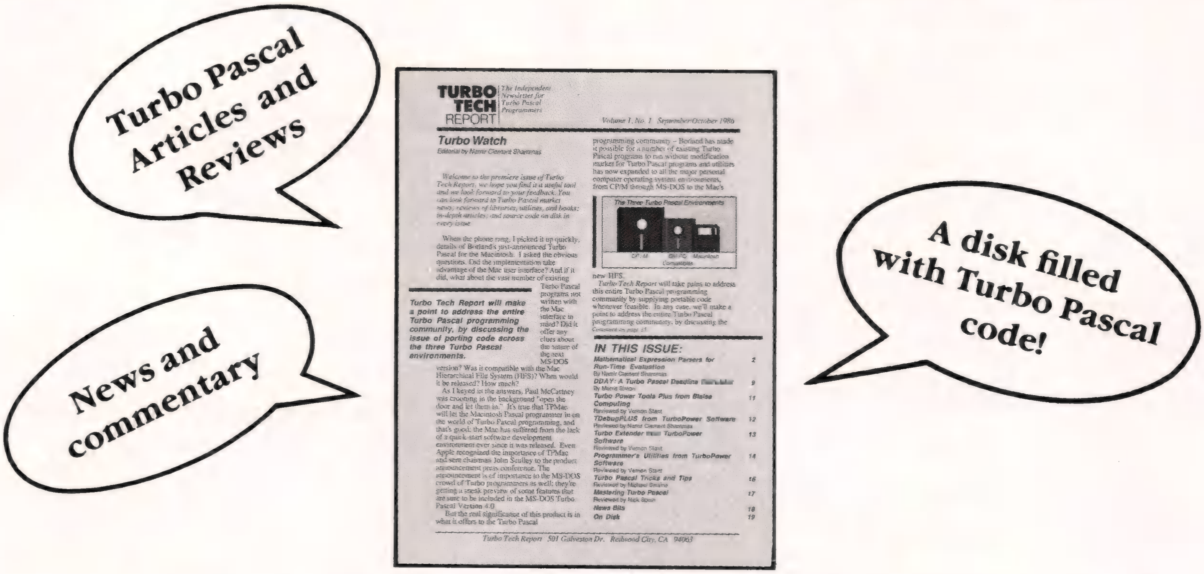

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Listing Three *(Text begins on page 46.)*

```
/*
 *
 *                              FINDCMD
 *
 *                         MODULE: STATE.C
 *
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 *
 */


/*
 *      This module contains the routines nesessary
 *      to implement the state machine
 */
#include        <stdio.h>

#include        "findcmd.h"

static  int     tos = -1;
static  int     pat[ 100 ];
static  struct  stk     stk[ 100 ];

/*
 *      INITS: initialize the state machine (transition table)
 */
inits( p )
char    *p;
{
        register int    i;

        i = 1;
        pat[0] = PATBEG;
        while( *p != NIL ){
                /*
                 *      Add each char in pattern to state array
                 */
                switch( *p ){
                case '?':
                        pat[i] = QUEST;
                        break;
                case '*':
                        pat[i] = ASTER;
                        break;
                default:
                        pat[i] = *p;
                        break;
                }
                p++;
                i++;
        }
        pat[i] = PATEND;

        return( 0 );
}

/*
 *      STATE: driving routine for the state machine;
 *              performs the actual pattern matching.
 */
state( n )
char    *n;
{
        register int    state;
        char    *ptr;

        ptr = n;
        tos = -1;
        state = 0;
        for(;;){                                /* Forever */

                switch( pat[state] ){
                case PATBEG:                    /* Begin state */
                        break;
```

```
        case ASTER:                         /* Wild card */
                if( *(ptr+1) != NIL ){
                        /*
                         *      Save machine state
                         */
                        PUSH( state-1, ptr+1 );
                }
                while( (*ptr != pat[state+1]) && (*ptr != NIL) ){
                        /*
                         *      Skip non-matching chars
                         *      up to end of string
                         */
                        ptr++;
                }
                break;

        case PATEND:                        /* End state */
                if( *ptr == NIL ){
                        /*
                         *      Match!
                         */
                        return( 1 );
                } else if( TOS ){
                        /*
                         *      No match - restore saved state
                         */
                        POP( state, ptr );
                } else {
                        /*
                         *      No match!
                         */
                        return( 0 );
                }
                break;

        case QUEST:                         /* Any 1 character */
                ptr++;
                break;

        default:
                if( *ptr != pat[state] ){
                        if( TOS ){
                                /*
                                 *      Restore saved state
                                 */
                                POP( state, ptr );
                        } else {
                                /*
                                 *      Fail - no match!
                                 */
                                return( 0 );
                        }
                } else {
                        /*
                         *      Equal - move on
                         */
                        ptr++;
                }
                break;
        }
        state++;                            /* Next state */
    }
}
```

End Listing Three

Listing Four

```
/*
 *
 *                      FINDCMD
 *
 *                  MODULE: FINDCMD.H
 *
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 *
 */
```

(continued on next page.)

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Listing Four *(Listing continued, text begins on page 46.)*

```
/*
 *      Header file for FINDCMD.C
 */
#define NIL     '\0'
#define FLDSEP  ';'                     /* dir separator in path */
#define MAXPATH 250

/*
 *      Machine states
 */
#define ASTER   128
#define QUEST   129
#define PATBEG  130
#define PATEND  131

/*
 *      DOS file attribute bits
 */
#define RDONLY  0x01                    /* Read only file */
#define HIDDEN  0x02                    /* Hidden file */
#define SYSTEM  0x04                    /* System file */
#define DIRECT  0x10                    /* Directory file */
#define ARCHIV  0x20                    /* Archive bit */

#define SA_SIZE(foo)    (sizeof(foo)/sizeof(foo[0]))

/*
 *      Macros for stack manipulation
 */
#define TOS             (tos == -1 ? 0 : 1)
#define POP(x,y)        {x = stk[tos].state; y = stk[tos].ptr; tos--; }
#define PUSH(x,y)       { tos++; stk[tos].state = (x); stk[tos].ptr = (y); }

char    *slcase();

/*
 *      Internal DOS date structure
 */
struct dosdate {
        unsigned sec    : 5;            /* Second (intervals of 2) */
        unsigned min    : 6;            /* Minutes */
        unsigned hour   : 5;            /* Hours */
        unsigned day    : 5;            /* Day of month */
        unsigned month  : 4;            /* Month of year */
        unsigned year   : 7;            /* Year since 1980 */
};


/*
 *      DOS FCB / DIR ENTRY - Set to DTA
 */
struct  dirent  {
        char    dinfo[ 21 ];
        char    dattr;
        struct  dosdate ddate;
        long    dsize;
        char    dname[ 13 ];
};
/*
 *      Used to print attribute bits of files
 */
struct attribs {
                int     val;
                int     chr;
};

/*
 *      Used to save an restore machine state
 */
struct  stk     {
        int     state;
        char    *ptr;
};
```

End Listings

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Listing One *(Text begins on page 140.)*

```
Listing 1.  QuickBASIC library to implement opaque matrices.

' QuickBASIC implementation of an opaque numeric matrix
' Matrix is stored as arrays of columns
' OPTION BASE 0 must be used, although the row/column indices
' start at one.

SUB InitMat(Mat#(1), Max.Row%, Max.Col%) STATIC
' Initialize matrix

Mat#(0) = Max.Row% + Max.Col% / 1000

FOR I% = 1 TO UBound(Mat#)
   Mat#(I%) = 0
NEXT I%

END SUB ' CreateMat

SUB StoreElem(Mat#(1), Row%, Col%, Elem#, OK%) STATIC

' Store Elem# in matrix position (Row%,Col%)
' OK% is zero if error has occurred, -1 if operation was done

STATIC I%, MaxR%, MaxC%

MaxR% = INT(Mat#(0))
MaxC% = 1000 * (Mat#(0) - MaxR%)

IF (MaxR% < Row%) OR (MaxC% < Col%) OR (Row% < 1) OR (Col% < 1) THEN
   OK% = 0 ' Bad row or column numbers.
   EXIT SUB
END IF

OK% = -1

' Calculate index
I% = Row% + (Col% - 1) * MaxR%
' for the arrays of rows representation use
'    I% = Col% + (Row% - 1) * MaxC%


' Store element
Mat#(I%) = Elem#

END SUB ' StoreElem

SUB RecallElem(Mat#(1), Row%, Col%, Elem#, OK%) STATIC

' Recall Elem# in matrix position (Row%,Col%)
' OK% is zero if error has occurred, -1 if operation was done

STATIC I%, MaxR%, MaxC%

MaxR% = INT(Mat#(0))
MaxC% = 1000 * (Mat#(0) - MaxR%)

IF (MaxR% < Row%) OR (MaxC% < Col%) OR (Row% < 1) OR (Col% < 1) THEN
   OK% = 0 ' Bad row or column numbers.
   EXIT SUB
END IF

OK% = -1

' Calculate index
I% = Row% + (Col% - 1) * MaxR%
' for the arrays of rows representation use
'    I% = Col% + (Row% - 1) * MaxC%

' Recall element
Elem# = Mat#(I%)

END SUB ' RecallElem
```

End Listing One

Listing Two

```
Listing 2.  True BASIC module that implements an array-based binary tree.

MODULE  Binary_Tree

! TRUE BASIC module that implements a single binary tree
! Copyright (c) 1987  Namir Clement Shammas

DECLARE DEF NIL, TRUE, FALSE
SHARE Left(1), Right(1), Node_Count, Num_Nodes, Bin_Tree$(1)


!------------ Module initialization ---------
LET Num_Nodes = 0

!----------- local functions -----------
DEF NIL = MAXNUM
DEF TRUE = 1
DEF FALSE = 0


SUB Initialize(Item$)
! Subroutine to initialize the binary tree

LET Num_Nodes = 1
LET Tree_Size = 1
LET Bin_Tree$(1) = Item$
LET Left(1) = NIL
LET Right(1) = NIL

END SUB


SUB Search(Item$, Found, Index)
! Search for Item$ and return Index if found.
```

(continued on page 113)

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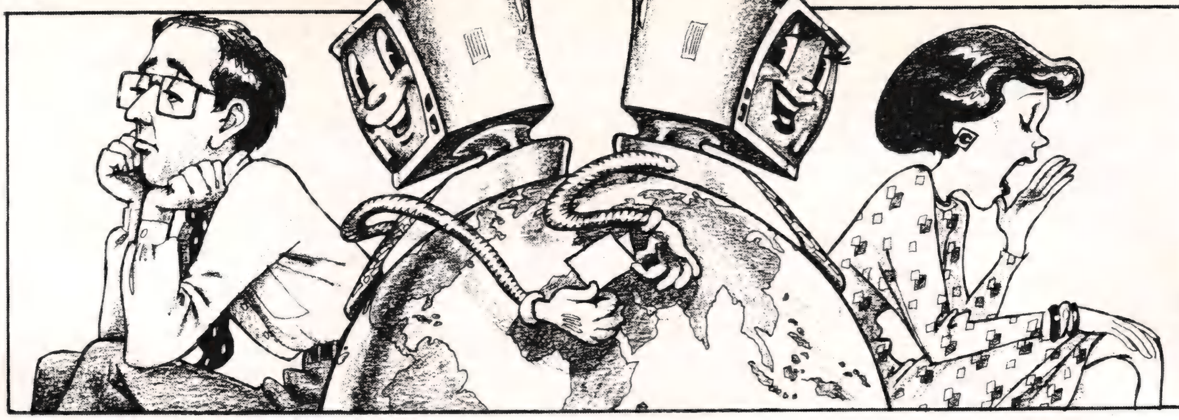

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Listing Two *(Listing continued, text begins on page 140.)*

```
LET Found = FALSE
LET Index = 1

DO WHILE (Index <> NIL) AND (Found = FALSE)
   IF Bin_Tree$(Index) = Item$ THEN
      LET Found = TRUE
   ELSE
      IF Bin_Tree$(Index) < Item$ THEN
         LET Index = Right(Index)
      ELSE
         LET Index = Left(Index)
      END IF
   END IF
LOOP

END SUB


SUB Insert(Item$)
! Insert Item$ in the "dynamic" binary tree structure

LET Num_Nodes = Num_Nodes + 1

IF Num_Nodes > Tree_Size THEN
   LET Tree_Size = Num_Nodes
   MAT REDIM Bin_Tree$(Tree_Size), Left(Tree_Size), Right(Tree_Size)
END IF

LET Index = 1
LET Found = FALSE

DO WHILE Index <> NIL
   IF Bin_Tree$(Index) < Item$ THEN
      IF Right(Index) <> NIL THEN
         LET Index = Right(Index)

      ELSE
         LET Right(Index) = Num_Nodes
         LET Index = NIL
      END IF
   ELSE
      IF Left(Index) <> NIL THEN
         LET Index = Left(Index)
      ELSE
         LET Left(Index) = Num_Nodes
         LET Index = NIL
      END IF
   END IF
LOOP

LET Bin_Tree$(Num_Nodes) = Item$
LET Right(Num_Nodes) = NIL
LET Left(Num_Nodes) = NIL

END SUB

END MODULE
```

End Listing Two

Listing Three

```
Listing 3.  Pascal code for emulating opaque complex data types.


TYPE
    Opaque_Complex_type = ^Opaque_Complex_type_record;

    { record type is deliberately empty }
    Opaque_Complex_type_record = RECORD
                                 END;
```

(continued on next page)

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Listing Three *(Listing continued, text begins on page 140.)*

```
    Actual_Complex_type = ^Actual_Complex_type_record;

    Actual_Complex_type_record = RECORD
                                   Reel,
                                   Imag : REAL;
                                 END;

    Convert_Complex = RECORD
                        CASE BOOLEAN OF
                            TRUE  : (Opaque : Opaque_Complex_type);
                            FALSE : (Actual : Actual_Complex_type)
                        END;


FUNCTION Convert_Opaque_to_Actual( Opaque_Complex : Opaque_Complex_type ) :
                                   Actual_Complex_type;

VAR Transfer : Convert_Complex;

BEGIN
    Transfer.Opaque := Opaque_Complex;
    Convert_Opaque_to_Actual := Transfer.Actual
END; { Convert_Opaque_to_Actual }



FUNCTION Convert_Actual_to_Opaque( Actual_Complex : Actual_Complex_type ) :
                                   Opaque_Complex_type;

VAR Transfer : Convert_Complex;

BEGIN
    Transfer.Actual := Actual Complex;
```


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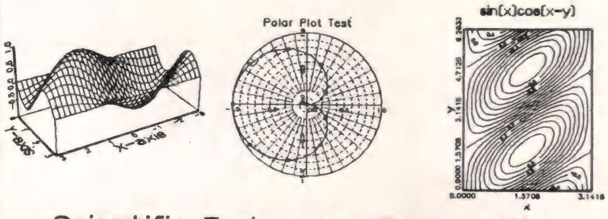

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```
    Convert_Actual_to_Opaque := Transfer.Opaque
END; { Convert_Actual_to_Opaque }



FUNCTION Real_Imag_Complex(Re, Im : REAL) : Opaque_Complex_type;
{ Convert from Real/Imaginary numbers to opaque complex numbers }
VAR Transfer : Actual_Complex_type;

BEGIN
    NEW(Transfer);
    Transfer^.Reel := Re;
    Transfer^.Imag := Im;
    Real_Imag_Complex:= Convert_Actual_to_Opaque(Transfer);
END; { Real_Imag_Complex }


FUNCTION Polar_Complex(Angle, Modulus : REAL) : Opaque_Complex_type;
{ Convert from polar coordinates to opaque complex numbers }
VAR Transfer : Actual_Complex_type;

BEGIN
    NEW(Transfer);
    Transfer^.Reel := Modulus * SIN(Angle);
    Transfer^.Imag := Modulus * COS(Angle);
    Real_Imag_Complex:= Convert_Actual_to_Opaque(Transfer);
END; { Polar_Complex }



PROCEDURE Get_Real_Imag(MyComplex : Opaque_Complex_type;
                        VAR Re, Im : REAL { output});
{ Convert opaque complex numbers into Real/Imaginary components }
VAR Transfer : Actual_Complex_type;
```

(continued on next page)

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Listing Three *(Listing continued, text begins on page 140.)*

```
BEGIN
    Transfer := Convert_Opaque_to_Actual(MyComplex);
    Re := Transfer^.Reel;
    Im := Transfer^.Imag;
END; { Get_Real_Imag }


PROCEDURE Get_Polar(MyComplex : Opaque_Complex_type;
                    VAR Angle, Modulus : REAL { output});
{ Convert opaque complex numbers into polar components }
VAR Transfer : Actual_Complex_type;

BEGIN
    Transfer := Convert_Opaque_to_Actual(MyComplex);
    WITH Transfer^ DO BEGIN
        Modulus := SQRT(SQR(Reel) + SQR(Imag));
        Angle   := Imag / Reel;
    END; { WITH }
END; { Get_Polar }



FUNCTION Add_Complex(C1, C2 : Opaque_Complex_type) : Opaque_Complex_type;


VAR Transfer : Actual_Complex_type;
    Re, Im : REAL;

BEGIN
    { Get first complex number }
    Transfer := Convert_Opaque_to_Actual(C1);
    Re := Transfer^.Reel;
    Im := Transfer^.Imag;
    { Get second complex number }
    Transfer := Convert_Opaque_to_Actual(C2);
    Re := Re + Transfer^.Reel;
    Im := Im + Transfer^.Imag;
    { Update result }
    Transfer^.Reel := Re;
    Transfer^.Imag := Im;
    Add_Complex := Convert_Actual_to_Opaque(Transfer);
END; { Add_Complex }
```

End Listing Three

Listing Four

```
Listing 4.  Modula-2 code for opaque complex data types.


DEFINITION MODULE Complex;

EXPORT QUALIFIED Complex, RealImagComplex, PolarComplex,


TYPE  Complex; (* opaque type *)


PROCEDURE RealImagComplex(Re, Im : REAL) : Complex;
(* Convert from Real/Imaginary numbers to opaque complex numbers *)

PROCEDURE PolarComplex(Angle, Modulus : REAL) : Complex;
(* Convert from polar coordinates to opaque complex numbers *)

PROCEDURE GetRealImag(MyComplex : Complex; VAR Re, Im : REAL (* output *));
(* Convert opaque complex numbers into Real/Imaginary components *)


PROCEDURE GetPolar(MyComplex : Complex; VAR Angle, Modulus : REAL (* output*));
(* Convert opaque complex numbers into polar components *)

PROCEDURE AddComplex(C1, C2 : Complex) : Complex;

END Complex.
```

(continued on page 119)

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Listing Four *(Listing continued, text begins on page 140.)*

```
IMPLEMENTATION MODULE Complex;

FROM MathLib0 IMPORT sqrt, sin, cos;

TYPE

    ComplexRecord = RECORD
                       Reel,
                       Imag : REAL;
                    END;

    (* opaque type mus be a pointer *)
    Complex = POINTER TO ComplexRecord;

PROCEDURE RealImagComplex(Re, Im : REAL) : Complex;
(* Convert from Real/Imaginary numbers to opaque complex numbers *)

VAR C : Complex;

BEGIN
    NEW(C);
    C^.Reel := Re;
    C^.Imag := Im;
    RETURN(C)
END RealImagComplex;

FUNCTION PolarComplex(Angle, Modulus : REAL) : Complex;
(* Convert from polar coordinates to opaque complex numbers *)

VAR C : Complex;

BEGIN
    NEW(C);
    C^.Reel := Modulus * sin(Angle);
    C^.Imag := Modulus * cos(Angle);
    RETURN(C)
END PolarComplex;

PROCEDURE GetRealImag(MyComplex : Complex; VAR Re, Im : REAL
                                            (* output *));
(* Convert opaque complex numbers into Real/Imaginary components *)

BEGIN
    Re := MyComplex^.Reel;
    Im := MyComplex^.Imag;
END GetRealImag;


PROCEDURE GetPolar(MyComplex : Complex; VAR Angle, Modulus : REAL
                                                 (* output*));
(* Convert opaque complex numbers into polar components *)
BEGIN
    WITH MyComplex DO
      Modulus := sqrt(Reel*Reel + Imag*Imag);
      Angle   := Imag / Reel;
    END;
END GetPolar;

PROCEDURE AddComplex(C1, C2 : Complex) : Complex;

VAR C : Complex;
    Re, Im : REAL;
BEGIN
    (* Get first complex number *)
    Re := C1^.Reel;
    Im := C1^.Imag;
    (* Get second complex number *)
    Re := Re + C2^.Reel;
    Im := Im + C2^.Imag;
    (* Update result *)
    C^.Reel := Re;
    C^.Imag := Im;
    RETURN(C)
END AddComplex;

END Complex.
```

End Listings

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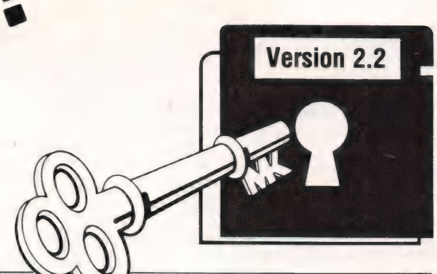

turn this into this!

```
C:>DEBUG PROGRAM.COM
-D100 136
8848:0100  EB 18 49 6E 63 6F 72 72-65 63 74 20 44 4F 53 20  k.Incorrect DOS
8848:0110  76 65 72 73 69 6F 6E 0D-0A 24 50 B4 30 CD 21 86  version..$P40M!.
8848:0120  E0 3D 36 01 72 05 3D 0A-02 76 09 BA 02 01 B4 09  `=6.r.=..v.:..4.
8848:0130  CD 21 CD 20 58 EB 2F                             M!M Xk/
-Q
```

```
H00100: JMP     Short H0011A                               ;00100 EB18           --
;-----------------------------------------------------------
        DB      "Incorrect DOS version"                    ;00102 496E636F727265
        DB      0Dh                                        ;00117
        DB      0Ah                                        ;00118
        DB      "$"                                        ;00119 24
;-----------------------------------------------------------
H0011A: PUSH    AX                                         ;0011A 50             P
        MOV     AH,30h                                     ;0011B B430           _0
        INT     21h               ;1-DOS_Ver_Number        ;0011D CD21           _!
        XCHG    AH,AL                                      ;0011F 86E0           __
        CMP     AX,0136h                                   ;00121 3D3601         =6_
        JB      H0012B            ; . . . . . . . . . .    ;00124 7205           r_
        CMP     AX,020Ah                                   ;00126 3D0A02         =__
        JBE     H00134            ; . . . . . . . . . .    ;00129 7609           v_
H0012B: MOV     DX,0102h                                   ;0012B BA0201         ---
        MOV     AH,09h                                     ;0012E B409           __
        INT     21h               ;1-Display_String        ;00130 CD21           _!
        INT     20h               ;TERM_normally:20h       ;00132 CD20           -
;-----------------------------------------------------------
H00134: POP     AX                                         ;00134 58             X
        JMP     Short H00166                               ;00135 EB2F           _/
;-----------------------------------------------------------


MASTER*KEY XREF - PROGRAM.XRF                                           Page 1

0102h                :    121   2F5   301   320
020Ah                :    126
03CBh                :    12B
1-Display_String     :    130   591   610
1-DOS_Ver_Number     :    11D
H00100               :    100
H0011A               :    100   11A
H0012B               :    124   12B
H00134               :    129   134
H00166               :    135
TERM_normally:20h    :    132
```

NOTE: The cross-reference is by memory location within the program file!

NOTE: The output is totally Microsoft MASM-compatible.

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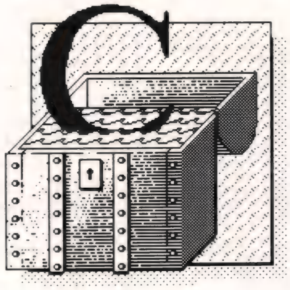
Language Wars Over Cs



There seems to be a plethora of new C compilers hitting the market at present. This month I'm going to look at four of them: Datalight's Optimum-C; Microsoft's Quick C; Microsoft's C compiler, Version 5.0; and Borland's Turbo C.

I'm going to take a different approach from most reviews and leave out the traditional tables and benchmarks. I'm doing this for several reasons. First, tables of features don't usually contain new information; you can read the advertisements as well as I can, and there's no point in my duplicating that information here. Next, I've found that benchmarks aren't a particularly reliable way to evaluate compilers. That is, a compiler that does poorly in compiling a single benchmark subroutine often does well when you use it for a large, complex program and vice versa. Also, raw speed is not the most important thing in a compiler, at least not to me.

As a programmer I spend most of my day trying to debug computer programs. Consequently, a good development environment is critical to me. I frankly don't care if my program takes 50 milliseconds longer to run or is 512 bytes larger than it could be, provided that I can minimize the time I spend in debugging and the

by Allen Holub

code quality is adequate. Most programs are I/O-bound anyway. That is, the fastest execution speed in the world doesn't speed up the rate at which you can update the screen or get input from a human being.

Of course, my own criteria may be different from yours. If you're doing engineering applications where you measure run time in hours rather than seconds, a few milliseconds here and there can be significant. If you fall into that category, the following reviews will still be useful but you should probably look at a review that has benchmarks, too.

All four compilers are quite good from the language perspective. They all support the complete C language (including bit fields), and they all incorporate various ANSI extensions, such as function prototypes and structure assignment. They all support floating point, including in-line 8087 code. They all include a version of the Unix make utility. They all come with the start-up module source code and have a good set of DOS interface functions. There are differences, however.

Optimum-C, Version 3.0

Datalight's Optimum-C is a pleasant surprise. First of all, it generates spectacularly good code—better than any of the other compilers reviewed here. It not only does the usual optimizations—such as constant folding, strength reduction, branch optimization, and aliasing—but it does some very sophisticated stuff too—constant and variable propagation, dead assignment elimination, automatic register allocation, global common subexpression elimination, loop invariant removal, and loop induction variables. The four basic memory models are supported (no huge or tiny), but mixed-model programming is difficult to do.

Optimum-C has good ROM support, though it doesn't come with the special linker that you need to locate specific segments in particular places in memory. (One of these days I'll write a linker for C Chest.) It provides an integer-only option that lets you compile without any floating-point support, and it provides you with a stripped-down start-up module that helps put together a ROMed environment.

Datalight includes a list of known bugs on the distribution disks. All compilers have bugs, but Datalight is honest enough to admit it, thereby helping you program around them. This honesty should be commended. It's a small thing, but it helps a lot when you want to get your program running.

The two drawbacks of Optimum-C are the lack of debugging support and a library that is too small. You pretty much have to rely on embedded *printf( )* statements to debug your programs. For this reason I don't really recommend the compiler if you're not already an experienced C programmer. The run-time library is adequate but just so. All the essential functions are there, but there's no gravy—for example, there's a *getenv( )* but no *putenv( )*. The library does include some useful stuff not found in the other compilers. There's a mouse-interface library and a set of interrupt-management functions that are useful for terminate-and-stay-resident utilities (Microsoft C has these too, however).

The compiler includes all the li-

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(continued from page 124)

brary sources and an adequate full-screen editor that might be useful if you don't have one already.

Quick C and Microsoft C, Version 5

I should preface my comments by saying that I'm looking at beta versions of both Quick C and the C compiler. Consequently, some of the things I'm saying here may become untrue later. (Both programs should be released in the final version by the time this article makes it into print.) I'll report back periodically as I get updates of these products. I'm also willing to give the people at Microsoft the benefit of the doubt, for the present. If they say something is going to be fixed, I'll believe them. Nonetheless, if the final version of the product still has problems, I'll discuss the problems in depth in this column.

The similarities between Quick C and Turbo C are unavoidable. They both include a development environment that incorporates an editor, compiler, and so forth. Neither of the editors is anything to write home about; both are adequate for fixing occasional errors that might pop up in debugging. Neither is really adequate for writing an actual program however, so you will probably do your initial typing outside the Quick C or Turbo C environment. In fact, these much-touted user interfaces are pretty worthless for the most part. I'd as soon use my own editor and compile with the command-line versions of the compilers. I see little point in wading through infinite menus when I can do the same job faster from the command line. How long can it take to learn a few command-line switches anyway? Fortunately, both Turbo and Quick C provide an easy-to-use, command-line version of the compiler.

There's a certain amount of overlap between Quick C and the full, Version 5, compiler, too. In fact, Quick C is included in the full compiler package. The main differences are code quality and compile time. The full compiler is slower, but it generates much better, heavily optimized code. Quick C, on the other hand, is lightning fast but the output code isn't great. There's also a new, much faster version of LINK provided with the package.

Both Quick C and the full compiler use the same libraries, literally—they use the same .lib files on the disk. This is a real boon if you're doing serious development work—you can use Quick C to develop individual modules, and once they're debugged, you can recompile with the full compiler to get better code quality.

Quick C provides a phenomenally good development environment. It has about three-quarters of CodeView built into it, so it not only finds syntax errors for you but it also helps you debug. You can use a command-line version of Quick C to generate CodeView-compatible files, however, so you can have both fast compile time and the full CodeView if you need it.

For those of you who aren't familiar with the CodeView debugger, it is a source-level debugger that really works, and it has become an essential part of my development environment. You can actually watch program execution at the source level; you can even see local and global variables change as they are modified. You can set breakpoints on variables being modified, on expressions becoming true, even on ranges of memory being modified. I discussed the debugger in depth in the November 1986 C Chest. My program development time has decreased by at least 25 percent since I started using this debugger. I can't live without it. Quick C is essentially CodeView with a compile instruction.

Quick C handles multiple-module files quite easily. You create a program list that has an entry for each file or library in the program. Quick C uses this list to create a makefile automatically and then assembles the program in a manner similar to the way make does (Turbo C uses a similar mechanism).

Quick C is really an incremental compiler not an interpreter. It compiles the entire module at lightning speed—comparable in all respects to Turbo C—without stopping. It has a "go to next error" function key in the editor that lets you find errors painlessly. It positions you at the line that contains the error, then prints the error message in a window at the bottom of the screen. A context-sensitive help feature gives you an on-line reference to all the library routines, showing you a function prototype and capsule description of any library function that is highlighted by the cursor.

The Microsoft run-time library, used by both Quick C and the full compiler, is the best out of those reviewed here. It is very Unix compatible and is packed with useful routines, including a set of graphics functions (new to this version) and very good support for terminate-and-stay-resident utilities (also new). The graphics functions let you do the basic stuff (lines, circles, ellipses, and area fill) and supports all the IBM video adapters (but, unfortunately, not the Hercules graphics card). The library documentation is among the best I've seen—better than that of any of the other compilers I'm reviewing here. It has one page per function, with the function name across the top of the page. The functions are listed in strict alphabetical order so that they're easy to find, and most entries have an example of how to use them.

Microsoft is finally selling the library source code too—useful if you're either porting to another environment or need to correct bugs that are bound to show up in the new routines. Microsoft is also accelerating the release schedule from yearly to semiannually so that you can get a compiler update with fixed bugs every six months instead of having to wait a year. This last change makes the library sources a little less important, but it's still good that they're being released.

Turbo C

Last, and least, on the list is Borland's Turbo C. I finally got my copy of Turbo C in the mail, several months after Borland had not only started advertising it but also collecting money for it. The cover letter started ominously with: ". . . right on schedule, here's Turbo C." In spite of the hype, however, and in spite of the seeming popularity of the product (at least judging by the sales figures), Turbo C comes in last when compared to the compilers I've just discussed. It's not so much that Turbo C isn't a good product but

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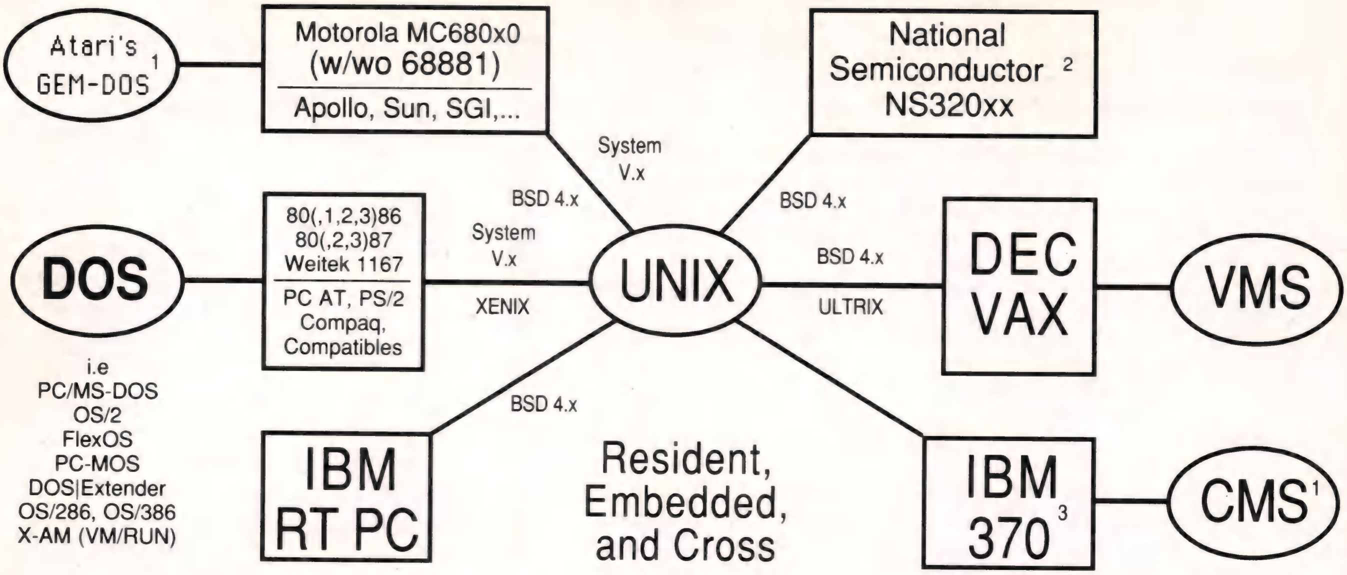

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C CHEST
(continued from page 126)

rather that the others are better.

Like Quick C, there are two interfaces to the compiler itself—a normal command-line interface and "the standard Borland integrated environment." The integrated environment is pretty worthless. Were I a Turbo Pascal user, I might like it better, but I'm not—the integrated environment does nothing but put extra steps between me and the compiled program. That is, it forces me to use an editor that I don't like; it forces me to wade through infinite menus to get anything done; and its menu system manages to make even simple things complex by adding too many steps to any process. Borland has made the classic mistake of confusing "user friendly" with "coddle the novice." The interface is only "friendly" until you know what you're doing.

The biggest problem with the integrated environment is the complete lack of debugging support. The product does find syntax errors for you, in a manner similar to Turbo Pascal. It puts you into the editor at the error point so that you can change things and finish the compilations. Syntax errors, however, are the least of it. It takes me a few minutes to get the syntax errors out of a program, but it can take days to get the program debugged, and Turbo C gives you absolutely no help with real debugging. It has nothing like the CodeView-like environment provided in Quick C.

So, once you get rid of the excess baggage, what you have is an inexpensive and reasonably good C compiler. The code quality is better than Microsoft C, Version 4, but not as good as Version 5. It supports all six memory models and lets you do mixed-model programming. It's easy to use from the command line and generates reasonably good code. Rumor has it that it's the Wizard C compiler, and looking at the generated code, I have no reason to doubt this supposition. The compiler supports in-line assembly language and has a reasonably good library, the sources for which are available if you need them. The DOS support is good but not portable, and there are no graphics functions.

The library has a few problems,

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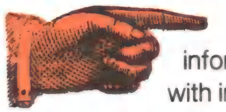

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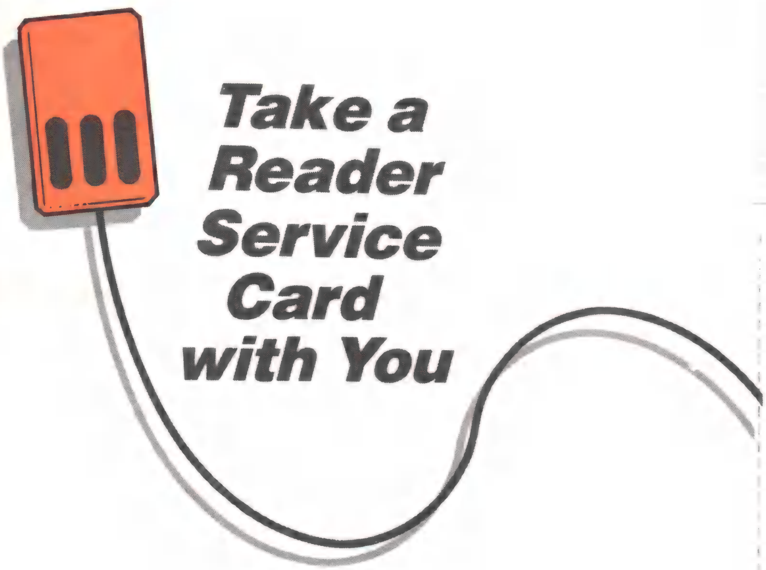

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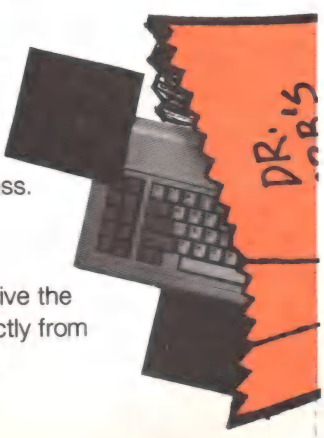

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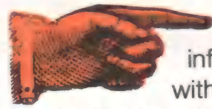

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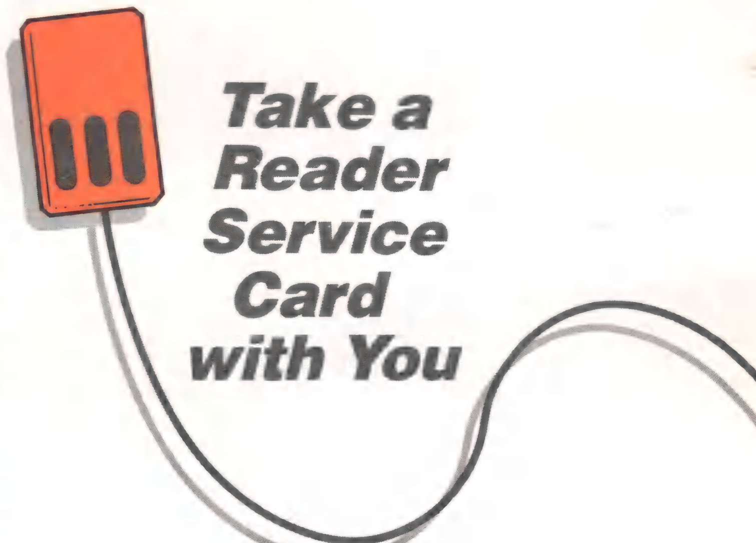

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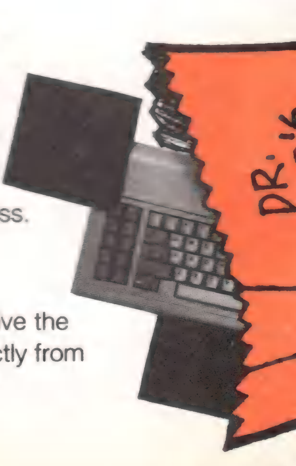

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C CHEST
(continued from page 128)

however, most of which fall into the Unix-compatibility and documentation areas. For example, there's no Unix-compatible *signal( )* function, though there is a nonstandard mechanism to intercept the Ctrl-Break interrupt; there's a function called *ioctl( )* but this function is nothing like the Unix function with the same name; and so forth. These sorts of incompatibilities always mystify me. It's easy enough to do it right, so why don't they?

The library documentation is adequate but not nearly as good as Microsoft's. There's lots of nonstandard stuff with little or no explanation of how that stuff works. For example, the nonstandard *ioctl( )* subroutine evidently lets you change file attributes, but the documentation doesn't tell you how. I assume that the *DOS Technical Reference* would help, but Borland's documentation doesn't say one way or the other. In addition, examples of how to use library routines are few and far between, and the documentation assumes a lot in terms of previous knowledge needed to figure out the subroutine description. A thorough knowledge of DOS interfacing details is assumed throughout.

The manual's layout is poor. Borland has saved space by putting the documentation for several subroutines on a single page, thereby making things harder to find (there's no header with the subroutine names for that page across the top). More often than not, when you look up a subroutine, the entry refers you somewhere else to get the actual description. There are a few typos that cause problems too—for example, the *stime( )* function is described as follows: "*stime* returns a value of 0 is returned."

Conclusion

Quick C in the stand-alone version is better than Turbo C. It does everything that Turbo C does, and then some, incorporating very good debugging support that is totally absent from Turbo C (finding syntax errors alone is not sufficient). My Quick C is a beta version, so I can't really compare code quality, and in any event, all of the products are more or less on par. Nonetheless, Turbo C is, at present, between Quick C (which is a little poorer) and the full Microsoft compiler (which is considerably better). Microsoft says that the code quality will be considerably improved in Quick C's final release.

To my mind, the better debugging environment provided by Quick C far outweighs any code-quality considerations. If you're doing serious development, you'll use the full compiler anyway. Quick C's debugging environment is particularly useful if you're learning the language.

Datalight's Optimum-C gives the best code quality of these four compilers, and the library, though small, is adequate for most programs. It also provides the best support for ROMed code, and the library sources are included for free. The lack of debugging support is a serious omission, however, and I recommend it primarily to experienced programmers who are generating code to run outside the DOS environment or to programmers who need very efficient code and don't care about the small library. I do recommend it, though, in spite of these shortcomings. It's a shame that Datalight's C generates Lattice-compatible assembly language rather than Microsoft-compatible. Were this not the case, you could use Quick C to do your development and Optimum-C for the final compilation pass.

The complete Microsoft compiler package is the most powerful, but it's by far the most expensive, especially when you add in the cost of the library sources. If cost is not an issue, I think the Microsoft compiler (which includes Quick C) is the best bet. It combines a very good compiler with a complete (and Unix-compatible) library and a fantastic debugging environment. If cost is an issue, or if you're just learning the language, I'd go with Quick C alone. If you're doing serious production work, get the full compiler package.

Bug Report

There is a bug on page 95 of the June column listings. On line 215, change *&item* to *item*.

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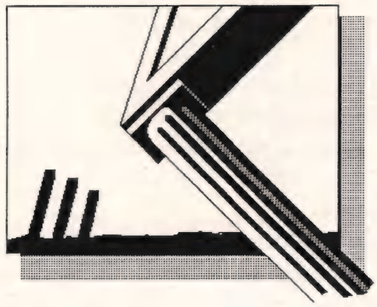

With this issue, DDJ *both inaugurates a new column and welcomes a new columnist to its ranks. Martin is eminently qualified to discuss the issues and nuances of the Forth language: he is one of the founders of MicroMotion, a senior programmer at FORTH Inc., and vice-president of the Forth Interest Group (FIG).—eds.*

Sure, you say, a column on Forth programming makes sense, but what's this business about news and reviews? Well, a lot has been happening lately. Forth is being used in everything from digital signal processing to neural nets. There are several Forth conferences each year (one near you) and hundreds of publications. You can find Forth in credit-card phones, cyclotrons, and on board the *Titanic*. Staying current can be a major task, but I'll try to keep you well informed and up to date.

There are four sources of Forth information that you should know about: the Forth Interest Group, The Institute for Applied Forth Research, various Forth electronic bulletin boards, and (of course) *DDJ*.

Forth Interest Group

The Forth Interest Group (FIG) brings together more than 4,000 Forth programmers and hobbyists in more

by Martin Tracy

than 80 local chapters. You can order just about any Forth publication through FIG, or find a job, or purchase group health insurance. FIG sponsors both the National Forth Convention and the Forth Modification Laboratory (FORML) conference. Membership is $30/year and includes a subscription to *Forth Dimensions*. You can join by calling the FIG hot line: (408) 277-0668.

The National Forth Convention is where you go to meet your local vendor and to learn more about FIG. More than 40 vendors attended last year, many with display booths. You can hear panels of Forth celebrities speculating about the future of the language. There are two days of technical presentations and a banquet, too. This year's convention meets November 14–15 at the Red Lion Inn in San Jose, California. The National Forth Convention is usually held one or two weeks before FORML so that visitors from abroad can reasonably attend both.

FORML

Imagine spending Thanksgiving this year in beautiful Monterey, California. FORML is *the* technical Forth conference and is held every year following Thanksgiving (November 27–29) at Asilomar in nearby Pacific Grove. Asilomar is a modern conference center situated in a pine forest overlooking the Pacific Ocean. There are raccoon and deer in abundance, and wine and cheese parties are held nightly. Although the technical content of FORML is quite advanced, the atmosphere is relaxed and informal.

The theme of this year's ninth FORML is "Forth and the 32-bit Computer." The call for abstracts (100 words or less) for the ninth annual FORML is September 1, 1987, so you've just missed it. Completed papers are due November 1, which means that if you call right away you might still be able to sneak in on time. You can call the organizers at (408) 277-0668.

The New Forth Dimensions

Actually, its pretty much the same old *Forth Dimensions* but with a new look that includes a glossy cover and a snappier format. *Forth Dimensions* is the bimonthly publication of FIG, and a one year's subscription is included with each annual membership. Some even say that FIG membership is free when you subscribe to *Forth Dimensions*. Volume IX, Number 1, starts the new look with articles on fractal landscapes, 32-bit Forths, and other topics. Marlin Ouverson, the editor, keeps a careful balance of beginning and advanced material, with tiny thermometers printed next to each to show you the level of difficulty.

This same issue includes an extended interview with Elizabeth Rather entitled "Starting FORTH Inc." If you want to know how it all got started, here's where to find out all about it. You might also be interested in Ray Duncan's series "Starting Your Own Software House" in *Programmer's Journal*. Ray is known to *DDJ* readers for his 16-bit Software Toolbox column, but he is also well known to the Forth community as the founder of Laboratory Microsystems Inc. (LMI) and the creator of PC/FORTH.

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(continued from page 132)

FIG and written in the Forth-83 standard dialect. The library is, in part, an ongoing experiment to determine the ability of the Forth-83 standard dialect to support substantial applications. Each participating vendor supplies an appropriate "front end" so that the application can run under its Forth. Needless to say, no machine-code words are used in the library. The emphasis is on readability and utility rather than on speed. Of course, you can always tune it more closely to your Forth or to your needs, hence the name *model*.

This library currently contains five volumes: *A Forth List Handler*, Volume 1, by Martin J. Tracy; *A Forth Spreadsheet*, Volume 2, by Craig A. Lindley; *Automatic Structure Charts*, Volume 3, by Kim R. Harris; *A Simple Inference Engine*, Volume 4, by Martin J. Tracy; and *The Math Box*, Volume 6, by Nathaniel Grossman. Volume 5, *A Complete PROLOG*, by Lou Odette, has been delayed but should appear shortly.

The Forth Model Library is available from FIG at $40 per volume. It is available on IBM MS-DOS 5¼-inch disks and runs under several IBM PC Forths, including Laxen/Perry (public domain) F83; PC/FORTH, Version 3.0 or later; MicroMotion MasterForth, Version 1.0 or later; and FORTH Inc.'s polyFORTH II MS-DOS ISD-4.

Fixed-Point Math

The Math Box, Volume 6 of the library, includes the source code for extended double-precision arithmetic; a complete fixed-point math package; auto-ranging text graphics; and utilities for rapid polynomial evaluation, continued fractions, and Monte Carlo factorization.

Forth programmers generally prefer fixed-point to floating-point math. For any given number size, fixed-point math is faster and more accurate than floating point but it lacks the convenience and larger dynamic range of floating point. Real-time applications that read transducers and write to D/A converters or stepper motor controllers usually have well-understood algorithms of limited dynamic range. PID controllers, digital filters, and computer graphics are especially amenable to fixed-point solutions.

A common Forth approach to implementing fixed-point numbers is to combine signed 16-bit integers and signed 14-bit fractions. A 14-bit fraction is a signed 16-bit number with the binary point two positions from the left:

```
S#.## #### #### ####
```

where *S* is the sign bit and each # is a binary digit. Fourteen-bit fractions have several charming properties:

- They can be added to each other with no adjustment.
- They can be multiplied by an integer with no adjustment.
- They can be multiplied together and adjusted with two left shifts.
- They can exactly represent +1 and −1, which is especially useful when working with sines and cosines.
- Because the number of bits is even and fixed, the square root is exact and

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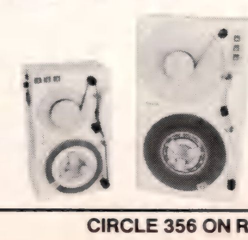

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does not require an extra multiplication.

You can read more about 14-bit fractions in Leo Brodie's *Starting Forth*, 2d ed (Englewood Cliffs, N.J.: Prentice-Hall, 1987). Don't bother trying to find the information in the first edition—it isn't there. By the way, *Starting Forth* has sold more than 110,000 copies. The second edition has been substantially revised and enlarged. It now identifies the differences between Forth dialects and includes a long-awaited index.

Unfortunately, neither 16-bit integers nor 14-bit fractions can represent handy numbers such as 3.1415 . . . . To combine efficiency with convenience, Dr. Grossman has designed a fixed-point package based on signed, 32-bit, fixed-point numbers with the binary point in the middle:

```
S### #### #### #### #### #### ####
                                ####
```

These numbers can range from more than 9,999 to less than 0.0001 with roughly 4½ digits on each side of the decimal point.

The 1987 Rochester Forth Convention

This year's Rochester Forth Convention was an impressive gathering of more than 100 Forth professionals from industry and academia. Although it was difficult for me to sit through 50 technical presentations (I admit I missed some), the four-day conference sped along, accompanied by excellent food and nightly parties. This year's conference, sponsored by the Institute of Applied Forth Research and coordinated by Larry Forsley, was a bit less organized than last year's, sadly because of Thea Martin's disinvolvement. Thea is leaving the institute to pursue a career in education.

This year's official theme was Forth hardware architecture, and the unofficial theme was artificial intelligence. Dr. Dorband (NASA Goddard Space Flight Center, Maryland) talked about the Massively Parallel Processor (MPP). This 128 × 128 array of 16,384 serial processors is programmed in (can you guess?) Forth. Dr. Ting (Lockheed) described an NCR GAPP network with a Novix 4016 as the microcode sequencer.

On a slightly smaller scale, Phil Koopman, Jr., demonstrated his Writable Instruction Set/Stack Oriented Computer (WISC), a 32-bit commercial Forth engine. Wright State University (Ohio) presented a stack-frame computer designed for Forth. Final silicon is expected in spring 1988. The university's stack-frame architecture has a shallow stack with all items directly addressable. ROT would be faster on this stack-frame computer than on, let's say, a Novix 4016. Speaking of Novix chips, George Nicol had an IBM AT stuffed with six Silicon Composer PC4000 boards running in parallel. Let's see, by my count that's 20 MIPS per board, for 120 MIPS. Is that Million Instructions Per Second or Misleading Information Provided by Sales? Also speaking of Novix chips, watch for good things from Harris Semiconductors, which has added the Novix to its macro cell library.

On the AI front, the University of Utah has been using an emulator written in Forth to test its Common

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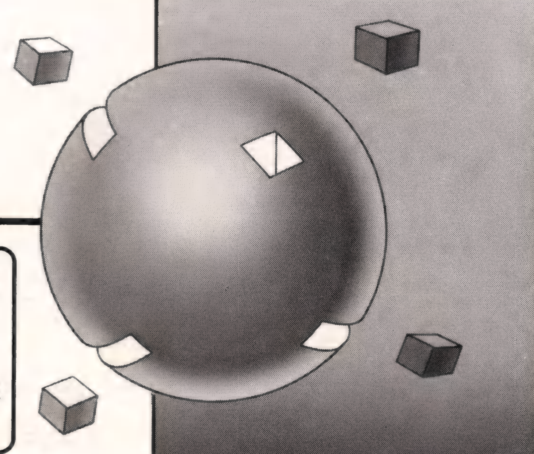

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THE FORTH COLUMN
(continued from page 135)

LISP compiler. Ecole Polytechnique de Montreal presented FUZZY-FORTH, a real-time fuzzy-rule production system. Henry Harris (Jet Propulsion Labs, California) gave a too-short talk on conceptual dependency. William Dress (Oakridge National Labs, Tennessee) brought a bug! Complete with a few hundred simulated neurons connecting simulated sensors with simulated muscles, this artificial neural network "insect" crawled around a CRT, learning to avoid the sides and to seek the simulated food. There were talks on computer-aided medical diagnosis, multiprocessor expert systems, and several other aspects of AI.

The last day of the conference was reserved for seminars and demonstrations. The peripatetic Ray Duncan demonstrated LMI's UR/FORTH for the Microsoft OS/2 operating system. Again and again (remember Creative Solution's MacFORTH?) Forth is one of the first languages to run in a new software environment.

If you missed the conference, you can still read the proceedings. They will appear shortly as a special issue of the *Journal of Forth Applications and Research* (*JFAR*). A one-year subscription (four issues) to this professional, refereed publication costs $40. You can order it from *JFAR*, P.O. Box 27686, Rochester, New York 14627.

For a Good Time . . .

If you own a modem, there are two numbers you should definitely investigate: the West Coast Forth Board ([213] 301-0761) in Los Angeles and the East Coast Forth Board ([703] 442-8695) in McLean, Virginia. These public-spirited nondenominational Forth bulletin boards contain megabytes of Forth utilities, interviews, contacts, and news. The WCFB sysops are Scott Squires (Lucasfilm), Michael Ham (of *DDJ* fame), and the ubiquitous Ray Duncan. The ECFB sysop is Jerry Shifrin (MCI).

Both boards are PCBOARD Forth-only bulletin-board systems. The ECFB is the more active of the two, averaging about two dozen messages a day. There are more than 1,000 Forth files available on this board! You can download the complete di-

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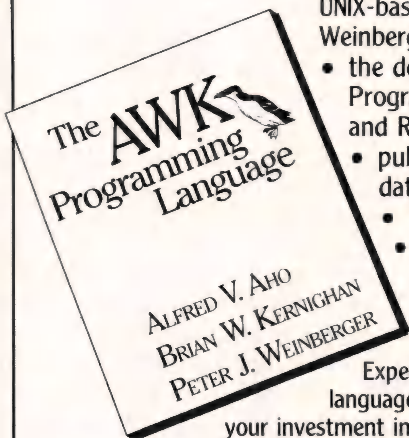

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(continued from page 137)

rectory listing in FILELIST.ARC. Many of these files are also available on the WCFB. Jerry Shifrin has put together an excellent 50-page *Guide to the ECFB*, which is available by leaving him a message on the board.

Product of the Month: Ashton-Tate's RapidFile

The following Forth success story was downloaded from the ECFB. Editorial comments are by Jerry Shifrin:

"Ashton-Tate has recently released RapidFile, a data management package for the IBM PC. The following is excerpted from Ashton-Tate's 3/87 issue of *Technotes*:

Technotes: Why is RapidFile written in FORTH?

Mark McDonough (developer): I'll tell you the story. When I told my professors that I wanted to implement the QBE [IBM's Query By Example] concept on a PC, I was told it was not possible. Knowing that it couldn't be done, I went out to find a genius who would know how to push the PC to its limits. I found that genius in Tom Dowling [of Miller Microsystems].

Tom claimed, and has since proven time and again, that FORTH was as easy to program in as other high level languages and that its programs run almost as fast as assembler programs. FORTH programs also compile into a very small space. We could not have fit RapidFile onto one disk and in 256K of RAM if it were written in C.

Technotes: We understand that the flexibility of FORTH really came in handy when designing RapidFile.

Steve Allin (product manager): Yes, FORTH is very tailorable. It allowed us to make substantial changes to the design. It is very close to being a prototyping language where you can make major changes much more easily than in standard programming languages, which would have required substantial rewrites. RapidFile went through several versions before its release and it couldn't have gone through all that if it hadn't been written in FORTH."

The ANS Forth Effort Begins

In October 1986, a small group from the Forth community met at FORTH Inc., Los Angeles, to submit a proposal to the American National Standards Institute (ANSI) asking it to undertake a Forth standard. This group consisted of major vendors (Elizabeth Rather, FORTH Inc.; and Ray Duncan, Lab Microsystems Inc.); major users (W. B. Dress, Oakridge National Laboratory; Burt Felis, IBM Corp.; and Jerry Shifrin, MCI Telecommunications Corp.), and interested experts (Charles Moore, inventor of Forth; Greg Bailey, Athena Programming; and yours truly). Also invited but unable to attend were Don Colburn (Creative Solutions), Dick Miller (Miller Microcomputer Services), and Kim Harris (Paradise Systems).

In February 1987, CBEMA (the ANSI organization responsible for ANS FORTRAN and the proposed ANS C), sent the ANS Forth proposal X3J14 to its general membership for a letter ballot. In April, CBEMA accepted the ANS Forth proposal. The following is from a letter by Ms. Rather to members of the proposing group:

"I am happy to report that the final vote for the establishment of X3J14, the Technical Committee for ANS Forth, was favorable: 36—1—1, with 2/3 approval required. An organizational meeting has been scheduled for August 3—4, 1987, at CBEMA headquarters, 311 First St., N.W., Washington, D.C. A newsletter to all ANSI members and a press release will be sent out May 1.

"At the first meeting, the staff of the X3 Secretariat will present a detailed tutorial on X3 and TC policies and procedures. Our first assignment will be to develop a detailed work plan and schedule for development of a draft standard."

Anyone may attend this meeting. According to ANSI rules, however, a voting member of a technical committee pays a yearly fee of $175 and must attend at least two out of three meetings to retain voting status. Furthermore, a technical committee (TC) generally meets two to four times a year in fairly distributed geographic locations. The frequency of meetings is part of the work plan decided at the first meeting. You can apparently team up with an alternate and thereby attend every other meeting without losing your vote.

While the direction of ANS Forth is yet to be determined by the yet-to-be-determined TC, the formal proposal calls for an integration rather than a revolution. The first item in the proposed work program is to "identify and evaluate common existing practices in the area of the Forth programming language." Wil Baden, former ANS FORTRAN committee member and well-known Forth orator, calls this "the principle of least surprise." Furthermore, the proposal continues, "while the Forth-83 Standard has stabilized the language to a great extent, it has proven too restrictive and machine-dependent. Assuming the ANS Forth standard confines itself to such changes as are necessary to resolve the problems in Forth-83, the effect on current practice will be modest." It was generally agreed that an ANS Forth might be a nice place to delete all references to a 16-bit parameter stack.

Meanwhile, Guy Kelly, chair of the Forth Standards Team (FST), has suggested that FST might serve as a clearinghouse for proposed extensions to Forth, such as string operators and floating-point arithmetic. Technical proposals should be sent to the Forth Standards Team, P.O. Box 4545, Mountain View, CA 94040. There is a form provided at the back of every published Forth-83 Standard. FST developed the Forth-79 and Forth-83 standards but has no further meetings scheduled at this time.

At any rate, by the time you read this, the first meeting will already have happened. I will try to keep you up to date on this heroic and historic event.

Coming Next

Next time around? More on the ANS Forth effort, a new bibliography on Forth, and a few surprises.

DDJ

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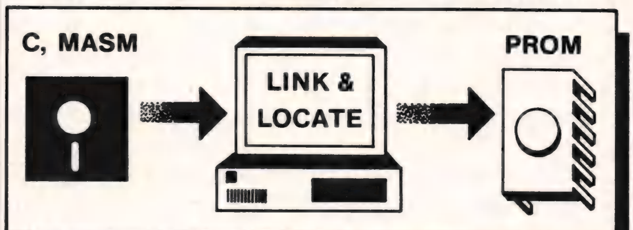

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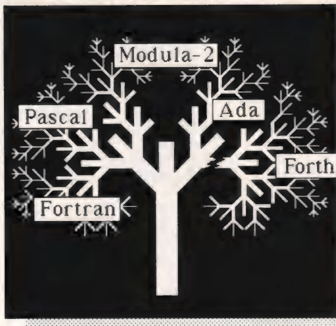

To trench-level programmers, the concept of data hiding is likely to be regarded with hostility—why deny full access to data structures? Unfortunately, data hiding is part of the baggage of modern software engineering, playing an important role in minimizing delays in application development. Because teams of programmers may spend thousands of man-hours writing code, strict control procedures can be vital to the successful management of complicated programming projects.

For example, when using either Ada or Modula-2, the first step in software coding begins with writing the definition modules, or packages. These modules list the exported data types, constants, variables, and routines. They will form the foundation upon which each team will develop the actual detailed modules and packages.

Careful planning must be exercised in the planning phase both to define and confine software development objectives. Each team should be able to work as independently as possible, thus yielding maximum productivity with minimum confusion. In the absence of data hiding, all exported data types and their variables have visible structures; this gives any team the ability to write their own routines and to manipulate the exported data structures.

by Namir Clement Shammas

But what happens if the team responsible for implementing a specific module and its data structures discovers a more efficient equivalent structure or decides that it absolutely has to modify the current one? The result is a domino effect of recoding by all the teams that used those modified data types. Keep in mind that this, too, is likely to create an entirely new set of problems!

To prevent this disastrous domino effect, opaque data types can be used. This gives the module or package implementor the freedom to alter the data structure without passing the negative effects on to other programmers. So what's the price for this?

Opaque data types must be accompanied by an adequate set of exported basic routines to manipulate them because client modules and programs cannot contain their own routines to access the components of an opaque type. This means that informed choices must be made in specifying which routines accompany the opaque types.

Data hiding is used with data structures that have alternate representations, such as:

- complex numbers represented by rectangular or polar components
- stacks implemented using arrays, a set of scalar variables (for small stacks), or a linked list
- lists implemented using pointers to dynamic data or to arrays
- binary trees implemented using pointers to dynamic data or to arrays
- two-dimensional matrices represented by arrays of rows or arrays of columns

Although data hiding is formally implemented in languages such as Ada and Modula-2, it can also prove useful to emulate this feature fully, or even partially, in other languages. This article looks at example applications in BASIC and Pascal and compares these implementations of data hiding to those in Ada and Modula-2.

The extent to which you can emulate data hiding in a particular language/implementation is dependent on two main ingredients: making the detailed data structure opaque, and denying the programmer access to the routines that manipulate the opaque data types. The first requirement is easily met by disguising the data structure; thus the trick is to hide the supporting code.

BASIC Examples

The QuickBASIC implementation produces a compiled user library that meets the more critical code-hiding requirement. You can use either arrays or large strings (QuickBASIC supports strings of up to 32K). Arrays are probably more suitable for tackling purely numeric data structures, whereas strings are more suitable for managing structures with numeric and alphanumeric data.

QuickBASIC supports packing of the basic numeric data types into fixed-length strings. Strickly speaking, QuickBASIC still enables you to access the components of the not-so-opaque data structure, but the schemes used would make such access a wasted effort. I call this type "logically opaque."

Listing One, page 110, shows the QuickBASIC library that implements

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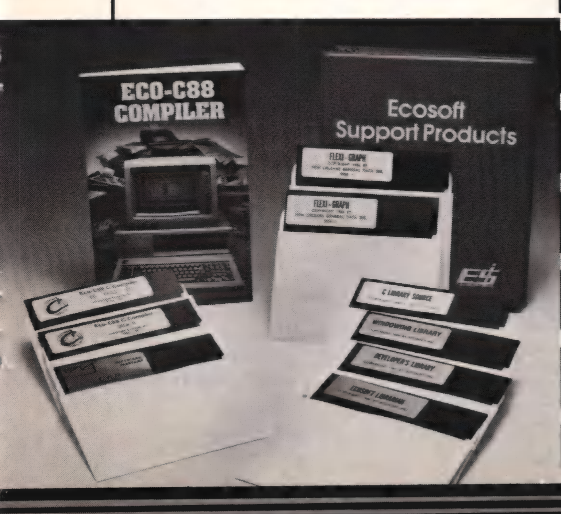

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ECOSOFT

(continued from page 140)

a version of the logically opaque numeric matrix. The matrix is made up of arrays of columns. Three procedures are used: one to initialize the matrix, one to store an element, and one to recall an element.

The scheme works with *OPTION BASE 0* to enable *Mat#(0)* to store the maximum number of rows and columns in the matrix structure. The opaque matrix should be declared as a one-dimensional array with *Max.Row% *Max.Col%* as its upper array bound. The routines are written such that the row and column indices of the opaque matrix start at 1. The routines for storing and recalling matrix elements contain commented code lines for implementing the arrays of rows. In this case, the changes are very simple.

The QuickBASIC code shows how you are still able to access the basic components of the data structure (that is, the individual array elements). With the compiled library version, however, the exact mapping of the matrix elements is invisible.

A second method that can be implemented in both QuickBASIC and Turbo BASIC revolves around static local strings or arrays. Both implementations support static declarations that can be used with local variables, which permits the BASIC subroutines to retain the data between subroutine calls. Example 1, below, shows the general scheme and how the subroutine in question is used to perform multiple tasks. The latter permits the BASIC subroutine to monopolize the opaque data structure. Other BASIC code segments can use the opaque data but are denied direct access. The same methods can be used with C and PL/I because they support static variables.

It's possible to emulate opaque types in Pascal by using pointers.

True BASIC is another BASIC implementation that supports a limited level of data hiding. True BASIC modules support an extension to ANSI BASIC that implements *SHARE* variables, which are characterized by their static nature and by the fact that they are accessible by all the module routines. These features enable programmers to perform partial data hiding.

Listing Two, page 111, shows an implementation of a binary tree in True BASIC. The module implements one instance of a binary tree. Three *SHAREd* arrays are used to manage the binary tree: *Bin_Tree$( )* stores the tree node data, *Left( )* is the array of left pointers, and *Right( )* is the array of right pointers. None of the three arrays are accessible by the application program using the binary tree, which makes the binary tree structure completely opaque.

```
SUB Jekyll.and.Hyde(<argument
      list>, Menu.Choice) STATIC

STATIC <list of scalar and
  arrays used to implement opaque
                       structure>

SELECT CASE Menu.Choice

  CASE 1

      <sequence of statements>

  CASE 2

      <sequence of statements>

  CASE 3

      <sequence of statements>

  ELSE

      <sequence of statements>

END SELECT

END SUB
```

***Example 1:** General scheme for using static local variables in QuickBASIC and Turbo BASIC*

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Pascal Examples

Although Pascal is similar to Modula-2, it does not support opaque types. Nevertheless, it is possible to emulate opaque types in Pascal by using pointers. Schneider[1] suggests the following method:

1. Declare an *opaque* record type and its pointer. This record declaration should be empty.
2. Declare a record type with the actual data structure used. Also declare a pointer type accompanying this record type.
3. Declare a variant record of the form:

```
TYPE Convert = RECORD
     CASE boolean OF
        TRUE : (Opaque : <pointer to
                         opaque record>);
        FALSE : (Actual : <pointer to
                         actual structure>)
END;
```

This variant record enables you to pass the addresses of pointers from one record pointer type to the other.

4. Provide two functions for two-way conversion between the opaque type and the actual data structure.
5. Write a set of routines that provide the required manipulation of the opaque data type.

Listing Three, page 113, shows Turbo Pascal data types and routines to implement opaque complex types. Five routines are provided for demonstration. The first two create complex numbers from rectangular or polar coordinates, and the following two perform the conversion in reverse. Function *Add_Complex* is a sample routine to perform a mathematical operation on a pair of complex numbers.

Notice how the input parameters that represent opaque complex numbers are first converted into the actual structures. True addition is performed using rectangular coordinates, and the results are converted into opaque complex numbers. The Pascal code prohibits the programmer from accessing the actual record type. This is enforced even further when using compiled library *UNIT*s because the actual record structure is confined to the implementation part of the library *UNIT*.

Compare the Pascal code with the Modula-2 version in Listing Four, page 116. Notice how simple and elegant the Modula-2 version looks compared to the Pascal version. In both Pascal and Modula-2, you can use the polar coordinates as the actual data structures without changing the parameters of the routines involved.

Availability

All the source code for articles in this issue is available on a single disk. To order send $14.95 to *Dr. Dobb's Journal*, 501 Galveston Dr., Redwood City, CA 94063, or call (415) 366-3600, ext. 216. Please specify the issue number and format (MS-DOS, Macintosh, Kaypro).

Note

1. M. Schneider, "Pascal Report," *Journal of Pascal, Ada and Modula-2*, vol. 5, no. 4 (July/August 1986).

DDJ

(Listings begin on page 110.)

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(continued from page 14)

posed of integers, unless you're a throwback to the Pythagoreans. Because of the nature of the problems people need to solve today, modern computer languages use sophisticated variables or object definitions, noninteger arithmetic operations, and advanced programming control techniques. Because computers do not support these functions, they must be emulated somehow by languages or programmers or both, and emulation is just a fancy word to describe a case in which a particular machine is made to do something it was not meant to do.

The exception to this is assembly languages, which are fully supported by the computers they are written for, but as anyone knows who's done enough "real programming," assembly language isn't the easiest language to program in, document, or maintain.

Therein lies the problem with computers and the reason why there are no good computer languages today and certainly no good general-purpose computer languages. Trying to tailor a machine that does one particular job well to do another job always leads to inefficiency, but instead of changing the approach, most people try and improve on just one aspect of the problem—the software.

We will not see any significant advance in the way we program computers until a computer architecture appears that supports a particular high-level language so fully that it would take more time and be less readable and maintainable to program in assembly language than to use the HLL. This architecture should be geared toward a particular type of task, such as object-oriented programming, real-time systems, or arithmetic number crunching, and should not support any operations that are not needed. Thus, we'll see two or three different types of computers, all with architectures supported by the right language to make the machines easy to program and as swift as possible.

People invent new languages to make the job easier, looking at the problem strictly from a software aspect. Instead, they should take a systems approach and think about the whole system—hardware and software—and produce a machine that gives the optimal solution to a particular type of problem. The new generation of computers should clear away the vast jungle of computer languages by introducing machines that are so tailored to one particular language that to use another one would be grossly inefficient. These new machines would not necessarily run any of the languages that are currently available. In fact, they probably won't. This doesn't mean that all computers will look like clones of three or four basic types. There will still be a lot of latitude in what type of I/O devices a particular system will support for a particular job or individual. But the computers will be efficient machines especially tailored to the task to be done, instead of Fords or Chevys passing off as Mercedes or BMWs.

There are microprocessors geared to run a particular language, but not everybody is convinced that programming in Forth or Modula-2 is the way to go, and in any case the problem should be approached from a system standpoint instead of just optimizing the microprocessor.

David Nakamoto
280 S. Euclid Ave., #315
Pasadena, CA 91101

Polytron Responds

Dear *DDJ*,

In the C Chest column in the May 1987 issue, Alan Holub briefly discussed the relative merits of Polytron's PolyMake and Lattice's LMK make utilities. He mentioned two problems that he was having with PolyMake—one relating to files existing in different directories and the other relating to memory usage.

I was unable to determine the exact nature of the directory problem that Mr. Holub mentioned. I can say, however, that we have literally thousands of users many of whom structure their projects hierarchically and apparently have no problem doing so with PolyMake. We use the same strategy internally at Polytron.

As regards Mr. Holub's comment about excessive memory usage, PolyMake has a feature that allows the user to determine how much memory it will consume. Use of this feature may have solved his problem.

Our customer support staff is very responsive to questions such as these that surface from time to time and would have been more than happy to help Mr. Holub resolve these "problems." Often all it takes is a simple phone call to resolve a perceived problem. When a genuine bug is discovered, we respond very quickly with a solution.

Incidentally, the current version of PolyMake is Version 2.1, and it contains many new and unique features in keeping with our market leadership position. These features include conditional constructs in both dependencies and operations, internal commands, shell control, some very powerful new macros, initialization operations, and the ability to determine time stamps of components of Polytron Version Control System (PVCS) archives and PolyLibrarian object module libraries. Also, Version 2.1 is about ten times faster and uses about 60 percent of the data space compared to PolyMake versions prior to Version 2.0.

Donald K. Kinzer
Polytron Corp.
1815 NW 169th Pl., Ste. 2110
Beaverton, OR 97006

Allen Holub replies:

I did call Polytron a year ago when I was having the directory problems discussed, and the staff couldn't come up with a solution then. Moreover, when I recently asked about the space-related problems, I was told that the new version (2.1) takes up even more memory than the version that I had. Mr. Kinzer's letter mentions that Version 2.1 uses 60 percent less data space, but he doesn't mention that it uses considerably more code space. Be that as it may, the added features may well make up for the amount of memory used. Polytron is sending me a copy of the new version, and I'll discuss it in a future C Chest.

DDJ

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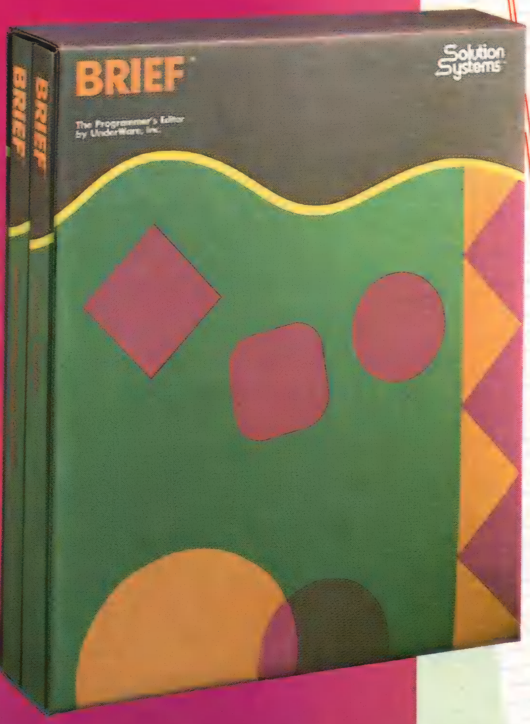

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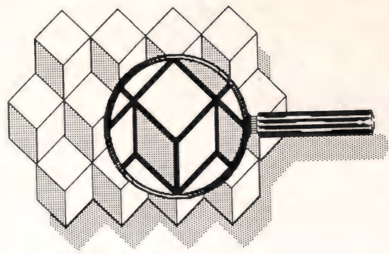

Languages

Language Processors has released a line of compilers for 386 machines running MS-DOS, Version 3.2. The languages currently available include LPI-COBOL, LPI-FORTRAN, LPI-RPG II, LPI-PL/I, LPI-PASCAL, and LPI-BASIC. Each product supports the 386 DOS-Extender from Phar Lap Software, which lets users run MS-DOS applications while facilitating access to the processing power of the 32-bit 386. Notable benefits include surmounting the 640K barrier, increasing overall performance, and enabling access of up to 4 Gbytes of memory.

Users who have developed applications using previous releases of LPI compilers will be able to transport those programs to 80386 machines running MS-DOS by recompiling them with the 386 version. Each compiler is priced at $695. Reader Service No. 16.

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JForth from **Delta Research** is based on the Forth-83 Standard and runs on the Commodore Amiga. Of particular interest is that high-level programs compile directly into machine code as opposed to interpreting tokens at run time. To cut development time, the compiler environment is interactive and allows incremental compiling. Utilities include a 68000 assembler and disassembler, search and sort routines, local variables, and floating point.

Amiga structures and constants are predefined in .j files, which correspond to the .h files used in C. Amiga library routines are called by name, and an object-oriented development environment is provided. Example programs demonstrate graphics, HAM mode, speech synthesis, and pull-down menus. Source code is furnished. JForth sells for $99.95. Reader Service No. 17.

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Microware Systems Corp. is now shipping its OS-9/68020 C compiler for the 32-bit Motorola 68020 microprocessor. Based on the Kernighan & Ritchie standard, the compiler includes extensions for the OS-9 operating system (for compact disc-interactive new media technology). All compiler/assembler/linker options are controlled by an "intelligent executive" that governs compiler options and module-calling sequences.

Extensions to the OS-9 operating system environment include library functions for memory management and systems events as well as several library functions that provide compatibility with the proposed ANSI standard. The compiler uses the MC68881 math coprocessor for high-speed execution of complex math functions and can generate in-line floating-point instructions, link to MC68881 math libraries, or trap to a shared systemwide MC68881 math package. It can also take advantage of the MC68020's 32-bit arithmetic instructions and special addressing modes. The OS-9/68020 C compiler includes both MC68000 and MC68020 code generation packages and sells for $750. Reader Service No. 18.

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Available add-on products include a C Language Standard Library, which allows programs written in C to be moved easily into the Modula-2 programming environment; Simplified Amiga Libraries, which includes functions for screen, window, sound, and device handling; Interchange File Format (IFF) Libraries; and Graphic Image Resource Management, consisting of both IFF libraries and the full documentation of the IFF format. The compiler sells for $199; the add-on products are available for $99 each. Reader Service No. 19.

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Tools

Jasik Designs is now shipping MacNosy, Version 2, and The Debugger for the Mac II. For those of you not familiar with the product, MacNosy is a global, interactive decompiler that lets you recover the source code of any Macintosh application. Standard MacNosy features include on-line access to the Macintosh system structures and/or current values and to Macintosh trap names (system calls) and their parameter lists and allow disassembly of all 680x0 instructions (including the 69991 FPU and 68851 MMU).

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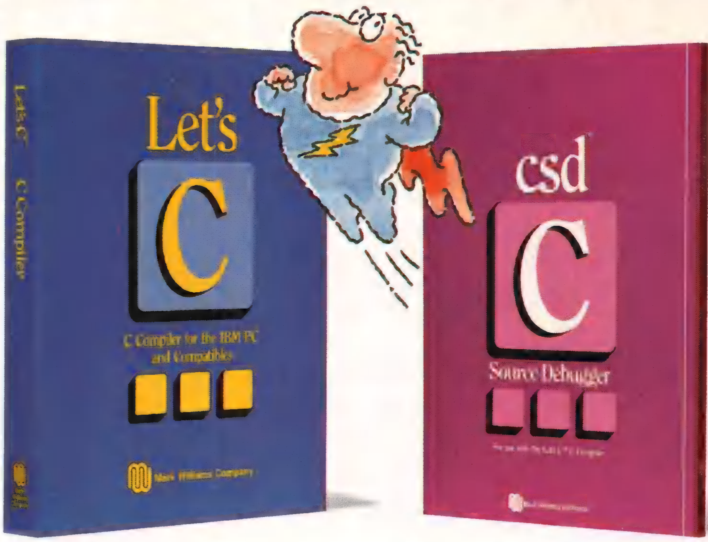

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(continued from page 146)

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Norwell, MA 02061
(617) 659-1571

MicroSolutions Computer Products has just released Version 2 of Uniform-PC, a utility that permits the use of more than 110 non-IBM PC disk formats on a standard PC/XT and more than 160 formats on an AT. Users of IBM PCs and compatibles can directly read, write, and initialize disks from most popular CP/M and MS-DOS computers. CP/M disks can be used just as though they were PC-DOS disks. New features include support for Apple CP/M, NorthStar CP/M hard-sector formats when used in conjunction with the new MatchPoint-PC, and MS-DOS formats from computers that do not use the IBM standard. Support is also provided for 48 TPI, 96 TPI, 8-inch, and 3.5-inch disk drives. Uniform-PC, Version 2, sells for $69.95. Reader Service No. 22.
MicroSolutions Computer Products
132 West Lincoln Highway
DeKalb, IL 60115
(815) 756-3411

Solutions International has just released SuperGlue, a graphics utility for the Macintosh that can be installed as a desk accessory and allows for font substitutions and text extraction from captured images. Images can be reduced or enlarged before they are printed to disk, and graphics can be automatically saved to a scrapbook file. The product has three parts: SuperImage Saver, a printer driver that prints text and graphics to disk as images; SuperViewer, a utility that allows users to open those images and print or copy them for use in other applications; and SuperViewerDA, a desk accessory version of SuperViewer. SuperGlue sells for $89.95. Reader Service No. 23.
Solutions International
29 Main St.
P.O. Box 989
Montpelier, VT 05602
(802) 229-9146

Hardware

ROMulator from **Grammar Engine** is, as its name implies, a ROM emulator. This hardware/software combination includes an in-circuit emulation module with associated cables and adapters along with the requisite host software. It can emulate standard (JEDEC) 24- and 28-pin ROMs, PROMs, and EPROMs; 8-, 16-, and 32-bit-word ROM modes; and supports daisy-chained modules of up to 8 ROMs. ROMulator software allows ROM software in Intel hex or Motorola S record format to be downloaded from any host via an RS-232 interface. When loaded, the software is then immediately available for access by the target system. Prices for the ROMulator (Model S256) start at $400. Reader Service No. 24.
Grammar Engine, Inc.
1021 Tipton Ct.
Westerville, OH 43081
(614) 882-6366

Applied Physics' BusMate PC/XT and BusMate AT cards offer hardware hackers or technicians effective tools for performing diagnosis on the PC bus system. Each card has a labeled gold pin for each signal line present on the bus and connections can be made to oscilloscopes, logic analyzers, or other test equipment that use standard test probes or microclips. Four light-emitting diodes monitor the system's power supply voltages. Each card also features a bus reset button that lets users reboot the system without powering down the machine. BusMate PC/XT sells for $79, and BusMate AT sells for $89. Reader Service No. 25.
Applied Physics Inc.
P.O. Box 2368
West Lafayette, IN 47906
(317) 497-1718

DDJ

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ai - expert systems

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EXSYS *Development Software by EXSYS*	395	309
EXSYS Runtime System	600	469
LEVEL5 *by Information Builders* ... *New*	685	569
Logic-Line Series *All varieties by Thunderstone*	CALL	CALL

ai - lisp language

	List	Ours
GCLISP *Golden Common LISP by Gold Hill*	495	CALL
GCLISP 286 Developer *by Gold Hill*	1190	CALL
Microsoft LISP *Common LISP*	250	149
QNIAL *Combines LISP & APL by NIAL Systems*	CALL	CALL
Sapiens MAKE & V8 ... *New*	439	379
Sapiens MAKE ... *New*	179	155
Sapiens V8 *Virtual Memory Manager* ... *New*	300	265
Star Sapphire LISP *Compiler by Sapiens* ... *New*	495	429
TransLISP PLUS *from Solution Systems*	195	125

ai - prolog language

	List	Ours
Arity Combination Package	1095	979
Expert System Development Pkg	295	229
File Interchange Toolkit	50	44
PROLOG Compiler & Interpreter	650	569
Screen Design Toolkit	50	44
SQL Development Package	295	229
Arity PROLOG Interpreter	295	229
Arity Standard Prolog	95	77
LPA microPROLOG *All Varieties*	CALL	CALL
MPROLOG Language Primer *LOGICWARE*	50	45
MPROLOG P500 *by LOGICWARE*	495	395
MPROLOG P550 *w/Primer by LOGICWARE*	220	175
Turbo PROLOG *by Borland Intl*	100	64
Turbo PROLOG Toolbox *by Borland Intl*	100	64

ai - smalltalk language

	List	Ours
Smalltalk/V	100	84
EGA/VGA Color Option	50	45
Goodies Diskette	50	45
Smalltalk/Comm	50	45

ai - texas instruments

	List	Ours
Arborist *Decision Tree Software*	595	519
PC Scheme *Lisp*	95	84
Personal Consultant Easy	495	435
Personal Consultant Image	495	435
Personal Consultant Online	995	869
Personal Consultant Plus	2950	2589
Personal Consultant Runtime	95	84

ada language

	List	Ours
AdaVantage *GSA-Validated by Meridian Software*	795	735
AdaVantage Utility Packages ... *New*	50	47
DOS Environment Package ... *New*	50	47
Janus/ADA C Pak *by R&R Software*	95	84
Janus/ADA D Pak *by R&R Software*	1250	1059
Janus/ADA ED Pak *by R&R Software*	395	349

apl language

	List	Ours
APL*PLUS PC *by STSC*	595	424
APL*PLUS PC Spreadsheet Mgr *by STSC*	195	139
APL*PLUS PC Tools Vol 1 *by STSC*	295	199
APL*PLUS PC Tools Vol 2 *by STSC*	85	58
APL*PLUS PS/2 *by STSC* ... *New*	595	424
ATLAS*GRAPHICS *by STSC*	450	329
Financial/Statistical Library *by STSC*	275	189
Pocket APL *by STSC*	95	69
STATGRAPHICS *by STSC*	895	649

assembly language

	List	Ours
386 ASM/LINK *Cross Asm by Phar Lap*	495	389
8088 Assembler *w/Z-80 Translator by 2500 AD*	100	89
ASMLIB *Function Library by BC Assoc*	149	125
asmTREE *B-Tree Dev System by BC Assoc*	395	329
Cross Assemblers *Various by 2500 AD*	CALL	CALL
EZASM *by C Source* ... *New*	70	59
Microsoft Macro Assembler ... *New Version*	150	93
Turbo Debugger *by Speedware* ... *New*	89	79
Turbo Editasm *by Speedware*	99	84
Visible Computer: 8088 *by Software Masters*	80	64

basic language

	List	Ours
87 Software Pak *by Hauppauge*	180	149
db/Lib *for QuickBASIC by AJS Publishing* ... *New*	139	119
Finally *by Komputerwerk*	99	85
MACH 2 *by Micro Help*	69	55
Microsoft QuickBASIC ... *$20 Rebate Until 10/15*	99	63
QBase *Relational Database by Crescent*	89	79
Quick-Tools *by BC Associates*	130	109
QuickPak *by Crescent Software*	69	59
Scientific Subroutine Library *by Peerless*	125	99
Screen Sculptor *by Software Bottling*	125	91
Stay-Res *by MicroHelp*	69	55
True Basic *w/Run-time* ... *Special Price*	200	99
True Basic	100	79
Run-time Module	100	79
Various Utilities	50	41
Turbo BASIC Compiler *by Borland Intl*	100	64

blaise products

	List	Ours
ASYNCH MANAGER *Specify C or Pascal*	175	135
C TOOLS PLUS/5.0 ... *New Version*	129	99
KeyPlayer *Super Batch Program* ... *New*	50	45
LIGHT TOOLS *for Datalight C*	100	65
PASCAL TOOLS	125	95
PASCAL TOOLS 2	100	79
PASCAL TOOLS & TOOLS 2	175	135
RUNOFF *Text Formatter*	50	45
TURBO ASYNCH PLUS	100	79
TURBO C TOOLS	129	99
TURBO POWER TOOLS PLUS	100	79
VIEW MANAGER *Specify C or Pascal*	275	199

borland products

	List	Ours
EUREKA *Equation Solver*	167	105
Reflex: The Analyst	195	128
Sidekick	85	57
Superkey	100	64
Turbo Basic Compiler	100	64
Turbo Basic Database Toolbox ... *New*	100	64
Turbo Basic Editor Toolbox ... *New*	100	64
Turbo Basic Telecom Toolbox ... *New*	100	64
Turbo C Compiler *(Call for support products)*	100	64
Turbo Lightning and Word Wizard	150	94
Turbo Lightning	100	64
Turbo Lightning Word Wizard	70	47
Turbo Pascal and Tutor	125	85
Turbo Pascal	100	64
Turbo Pascal Tutor	40	24
Turbo Pascal Database Toolbox	70	41
Turbo Pascal Editor Toolbox	70	41
Turbo Pascal Gameworks Toolbox	70	41
Turbo Pascal Graphix Toolbox	70	41
Turbo Pascal Jumbo Pack	300	219
Turbo Pascal Numerical Methods Toolbox	100	64
Turbo Prolog Compiler	100	64
Turbo Prolog Toolbox	100	64

c compilers

	List	Ours
C86PLUS *by Computer Innovations*	497	375
DeSmet C *w/Debugger & Large case*	209	184
DeSmet C *w/Debugger only*	159	138
Eco-C *Complete System by Ecosoft*	140	119
Lattice C Compiler *vers. 3.2 from Lattice*	500	265
Mark Williams Let's C w/csd	75	54
Microsoft C Compiler w/CodeView ... *New version*	450	269
Microsoft QuickC Compiler ... *New*	99	63
Optimum-C *by Datalight*	139	95
Turbo C Compiler *by Borland*	100	64
Uniware 68000/10/20 Cross Compiler *by SDS*	995	829

c interpreters

	List	Ours
C-terp *by Gimpel, Specify compiler* ... *New Version*	300	219
C Trainer *with Book by Catalytix*	122	87
Instant C *by Rational Systems* ... *New Version*	500	369
Introducing C *by Computer Innovations*	125	99
Run/C *by Age of Reason*	120	69
Run/C Professional *by Age of Reason*	250	145

c utilities

	List	Ours
Blackstar C Library *by Sterling Castle* ... *New*	99	78
C++ *by Guidelines w/version 1.1 kernel*	195	172
c-tree & r-tree Combo *by FairCom*	650	519
c-tree *ISAM File Manager*	395	315
r-tree *Report Generator*	295	239
Csharp Realtime Toolkit *by Systems Guild* ... *New*	600	539
Curses Window Dev Pkg *by Aspen Scientific* ... *New*	119	105
dBx *dBASE to C Translator by Desktop AI*	350	299
with Source Code ... *New*	550	419
Flash-up Windows *by Software Bottling*	90	78
GraphiC *Color version by Sci Endeavors*	350	274
GRAFLIB *by Sutrasoft*	175	159
HALO *Graphics by Media Cybernetics*	300	205
HALO Development Pkg *for Microsoft*	595	389
The HAMMER *by OES Systems*	195	129
PANEL *Forms Management by Roundhill*	295	215
PANEL/TC *for Turbo C by Roundhill* ... *New*	129	95
PANEL Plus *by Roundhill*	495	395
PC Lint *by Gimpel Software*	139	99
PHACT *from UniPress* ... *New*	249	229
PLOTHP *by Sutrasoft*	175	159
RTC PLUS *Fortran to C by Cobalt Blue*	450	399
Scientific Subroutine Library *by Peerless*	175	135
TE Text Editor *source by Sub Systems* ... *New*	95	85
Vitamin C *by Creative Programming*	225	158
VC Screen *Forms Designer*	100	79
Zview *by Data Mgmt Consultants*	245	139

cobol language

	List	Ours
COBOLspII *by Flexus*	395	329
FPLIB *for Realia COBOL by BC Associates*	149	129
Micro Focus COBOL *See Micro Focus Section*		
Microsoft COBOL *See Microsoft Section*		
PCDT *by Pro-Code* ... *New*	995	895
Realia COBOL with RealMENU ... *New Version*	1145	899
Realia COBOL ... *New Version*	995	783
RealCICS	995	783
RM/COBOL *by Ryan-McFarland*	950	CALL
RM/COBOL 85 *by Ryan-McFarland*	1250	CALL
RM/NET+5 *by Ryan-McFarland* ... *New*	300	CALL
RM/Screens ... *New*	395	CALL
SCREENIO *by Norcom*	400	379
screenplay *for COBOL by Flexus*	175	129

css products

	List	Ours
Combo Package *by Custom Software Systems*	199	175
PC/SPELL *Spelling Checker*	49	45
PC/TOOLS *UNIX-like Utilities*	49	45
PC/VI *vi Editor*	149	99

debuggers & profilers

	List	Ours
386 DEBUG *Cross Debugger by Phar Lap*	195	129
Advanced Trace-86 *by Morgan Computing*	175	115
Codesmith-86 *by Visual Age*	145	98
DSD87 *by Soft Advances*	125	79
MiniProbe *by Atron*	395	369
Periscope I *with Board by Periscope*	345	275
Periscope II *with NMI Breakout Switch*	175	139
Periscope II-X *Software only*	145	105
Periscope III *8 MHz version*	995	795
Periscope III *10 MHz version*	1095	899
The PROFILER *with Source Code by DWB*	125	89
TURBOsmith *Source debugger for Turbo Pascal*	69	59
The WATCHER *Profiler by Stony Brook*	60	51

disk utilities

	List	Ours
Back-It *by Gazelle Systems*	100	89
Disk Optimizer *by Softlogic Systems*	60	55
Disk Technician *by Prime Solutions* ... *New*	100	89
FASTBACK *by 5th Generation Systems*	179	129
Vcache *by Golden Bow Systems* ... *New*	50	47
Vopt *by Golden Bow Systems* ... *New*	50	47
Vfeature *by Golden Bow Systems* ... *New*	80	74
Vfeature Deluxe *by Golden Bow Systems* ... *New*	120	111
XenoCopy-PC *by XenoSoft*	80	69

dos utilities

	List	Ours
Advanced Norton Utilities	150	99
Command Plus *by ESP Software*	80	69
FANSI-CONSOLE *by Hersey Micro*	75	62
Mace Utilities *Paul Mace Software* ... *New*	99	89
MicroHelp Utility *by MicroHelp*	59	49
Norton Commander *by Peter Norton*	75	55
Norton Utilities *by Peter Norton*	100	59
OPAL *Shell Language by Software Factory*	99	89
Q-DOS II *by Gazelle Systems*	70	59
Taskview *by Sunny Hill Software*	80	55

essential products

	List	Ours
C Utility Library	185	119
Essential Comm Library *with Debugger*	250	189
Essential Comm Library *Software Only*	185	125
Breakout Debugger Only *Any language*	125	89
Essential Graphics	250	183

forth language

	List	Ours
CFORTH *Native Code Compiler by LMI*	300	229
FORTH/83 Metacompiler *Specify Target*	750	599
PC/FORTH *by Laboratory Microsystems*	150	109
PC/FORTH+ *by Laboratory Microsystems*	250	199
Programmer's Package #1 *by LMI* ... *New*	250	199
Programmer's Package #2 *by LMI* ... *New*	350	279
Programmer's Package #3 *by LMI* ... *New*	500	399
UR/FORTH *Also Available for OS/2 by LMI*	350	279
UR/FORTH Libraries	500	395

fortran language

	List	Ours
50 MORE: FORTRAN *by Peerless Scientific*	125	95
ACS Time Series *by Alpha Computer Service*	495	389
AUTOMATED PROGRAMMER *by KGK Automated* *New*	250	183
Essential Graphics *by Essential Software*	250	183
For-Winds *by Alpha Computer Service*	90	69
Forlib-Plus *by Alpha Computer Service*	70	44
FORTLIB *by Sutrasoft*	125	109
FORTRAN Addendum *by Impulse Engr*	95	85
FORTRAN Addenda *by Impulse Engr*	165	138
GRAFLIB *by Sutrasoft*	175	159
HALO *Graphics by Media Cybernetics*	300	205
I/O PRO *w/No Limit Library by MEF*	250	219
Microcompatibles Combo Package	240	215
Grafmatic	135	117
Plotmatic	135	117
Microsoft FORTRAN *w/CodeView*	450	269
No Limit Library *by MEF Environmental*	129	109
Numerical Analyst *by MAGUS*	295	249
PANEL *by Roundhill Computer Systems*	295	215
PLOTHP *by Sutrasoft*	175	159
RM/FORTRAN *by Ryan-McFarland* ... *New Version*	595	CALL
RTC PLUS *Fortran to C by Cobalt Blue*	450	399
Scientific Subroutine Lib *by Peerless*	175	135
Statistician *by Alpha Computer Service*	295	235
STATLIB.GL: *by Peerless* ... *New Version*	295	239
STATLIB.TSF: *by Peerless* ... *New Version*	295	239
Strings & Things *by Alpha Computer Service*	70	45

greenleaf products

	List	Ours
Greenleaf C Sampler *for Turbo C & QuickC* ... *New*	95	69
Greenleaf Comm Library	185	125
Greenleaf Data Windows Library	225	155
with Source Code	395	249
Greenleaf Functions	185	125

help utilities

	List	Ours
HELP/Control *by MDS*	125	99
On-line Help *from Opt-Tech*	149	99
SoftScreen/HELP *by Dialectic Systems*	195	149

lattice products

	List	Ours
Lattice C Compiler *ver 3.2 from Lattice*	500	265
with Library Source Code	900	495
C Cross Reference Generator	50	37
with Source Code	200	139
C-Food Smorgasbord *Function Library*	150	95
with Source Code	300	179
C-Sprite *Source Level Debugger*	175	119
Curses *Screen Manager*	125	85
with Source Code	250	169
dBC *Specify dBC II or dBC III*	250	169
with Source Code	500	356
dBC III Plus	750	594
with Source Code	1500	1184
LMK *Make Facility*	195	138
RPG II Combo *All three items below*	1100	875
RPG II Compiler *No Royalties*	750	625
SEU *Source Entry Utility*	250	199
Sort/Merge	250	199
Screen Design Aid Utility *for RPG II*	350	309
SecretDisk *File Encryption Utility*	120	88
SideTalk *Resident Communications*	120	88
SSP/PC *Scientific Subroutine Library*	350	269
Text Management Utilities	120	88
TopView Toolbasket *Function Library*	250	178
with Source Code	500	356

metagraphics products

	List	Ours
LightWINDOW/C *for Datalight C*	95	79
FontWINDOW	95	79
FontWINDOW/PLUS	275	229
MetaWINDOW *No Royalties*	195	159
MetaWINDOW/PLUS	275	229
TurboWINDOW/C *for Turbo C*	95	79
TurboWINDOW/Pascal *for Turbo Pascal*	95	79

micro focus products

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Micro Focus Level II COBOL *w/Animator*	495	395
Level II COBOL	349	279
Level II Animator	195	155
Micro Focus Level II COBOL/ET for UNIX	CALL	CALL
Micro Focus Personal COBOL	149	119
Micro Focus Professional COBOL	2000	1595
Micro Focus VS COBOL/XENIX	1495	1195
Micro Focus Support Products:		
COBOL/IQ *Ad hoc Report Writer*	495	395

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FORMS-2	295	235
SOURCEWRITER	995	795

microport products

386 Unlimited License Kit	249	209
AT Unlimited License Kit	249	209
DOSMerge286 *Run DOS and UNIX together*	149	125
DOSMerge386 *Run DOS and UNIX together*	CALL	CALL
System V/386 Combination	799	699
386 Runtime System	199	169
386 Software Development System	499	429
Text Preparation System	199	169
System V/AT Combination	549	465
AT Runtime System	199	169
AT Software Development System	249	209
Text Preparation System	199	169

microsoft products

Microsoft BASIC Compiler *for XENIX*	695	419
Microsoft BASIC Interpreter *for XENIX*	350	209
Microsoft C Compiler *w/CodeView* .... *New Version*	450	269
Microsoft COBOL Compiler *with COBOL Tools*	700	429
for XENIX	995	609
Microsoft FORTRAN *Optimizing Compiler/CodeView*	450	269
Microsoft FORTRAN *for XENIX*	695	419
Microsoft Learning DOS	50	36
Microsoft LISP *Common LISP*	250	149
Microsoft MACH 10 *with Mouse & Windows*	549	369
Microsoft MACH 10 *Board only*	399	279
Microsoft Macro Assembler .... *New Version*	150	93
Microsoft Mouse *for IBM PS/2* .... *New*	175	114
Microsoft Mouse *Bus Version*	175	114
Microsoft Mouse *Serial Version*	195	124
Microsoft muMath *Includes muSIMP*	300	179
Microsoft Pascal Compiler	300	179
for XENIX	695	419
Microsoft QuickBASIC .... *$20 Rebate Until 10/15*	99	63
Microsoft QuickC .... *New*	99	63
Microsoft Sort	195	125
Microsoft Windows	99	63
Microsoft Windows Development Kit	500	299
Microsoft Word	450	269

mks products

MKS AWK *Includes Book Offer until 10/30* ... *New*	75	65
MKS Toolkit *with MKSVI Editor*	139	114
MKSVI *Editor by MKS* .... *New*	75	65

modula-2 language

EXE2LNK *MASM Interface by PMI*	49	45
LOGITECH Modula-2 Development System.... *New*	249	199
Modula-2 Compiler Pack .... *New*	99	79
Modula-2 Toolkit .... *New*	169	139
LOGITECH Modula-2 ROM Pkg & X RT Debugger	299	239
LOGITECH Modula-2 Window Pkg	49	39
Macro2 *Macro preprocessor by PMI*	89	79
ModBase *by PMI*	89	79
ModGraph *by TEQNA* .... *New*	50	45
Repertoire *by PMI*	89	75
Science & Engrg Tools *by Quinn-Curtis*	75	67
Universal Graphics Library *by Quinn-Curtis*	150	119

mouse products

LOGIMOUSE BUS *with PLUS Pkg by LOGITECH*	119	98
with PLUS & PC Paintbrush	149	119
with PLUS & CAD Software	189	153
with PLUS & CAD & Paint	219	179
with First Publisher .... *New*	CALL	CALL
LOGIMOUSE C7 *with PLUS Pkg, Specify Connector*	119	98
with PLUS & PC Paintbrush	149	119
with PLUS & CAD Software	189	153
with PLUS & CAD & Paint	219	179
with First Publisher .... *New*	CALL	CALL
Microsoft Mouse *See Microsoft Section*		

other languages

ACTOR *by Whitewater Group*	495	419
CCS MUMPS *Single-User by MGlobal*	60	50
CCS MUMPS *Single-User Multi-Tasking*	150	129
CCS MUMPS *Multi-User*	450	359
Marshal Pascal *by Marshal Language Systems*	189	165
Pascal-2 *by Oregon Software*	395	325
Personal REXX *by Mansfield Software*	125	99
SNOBOL4+ *by Catspaw*	95	80

other products

Carbon Copy *by Meridian Technology* .... *New*	195	159
Dan Bricklin's Demo Pgm *by Software Garden*	75	57
Dan Bricklin's Demo Tutorial	50	45
Fast Forward *by Mark Williams*	70	59
Instant Replay *by Nostradamus*	150	CALL
MicroTEX *Typesetting from Addison-Wesley*	295	CALL
Net-Tools *by BC Associates*	149	129
Norton Guides *Specify Language* .... *New*	100	75
OPT-Tech Sort *by Opt-Tech Data Proc*	149	99
PC/TOOLS *by Custom Software*	49	45
Screen Machine *by MicroHelp*	79	59
SuperSort *by LifeStyle* .... *New*	139	119

phoenix products

Pasm86 *Macro Assembler version 2.0*	195	108
Pdisk *Hard Disk & Backup Utility*	145	99
Pfantasy Pac *Phoenix Combo*	995	595
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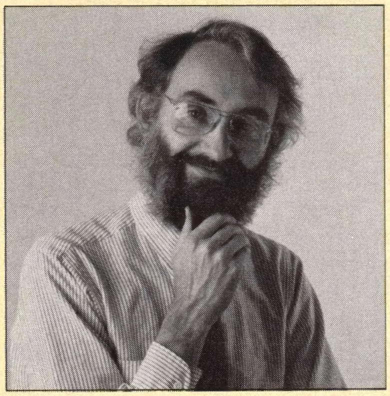
SWAINE'S FLAMES



Doesn't your heart just go out to Lotus Development Corporation? First everybody and his brother ripped off the Lotus 1-2-3 user interface. Then somebody hit on the idea of compiling 1-2-3 spreadsheets into objects that can be manipulated without 1-2-3, so that one copy of 1-2-3 may be all a company needs. And now the latest wrinkle in the spreadsheet counterpane: Microsoft has slipped in with a PC spreadsheet product that reads 1-2-3 files and converts 1-2-3 macros.

It reminds me of a story I wrote once.

Back when I worked for *InfoWorld* and VisiCalc and SuperCalc were in flower, I wrote a regular back-page column that posed mathematical puzzles in the format of mystery stories featuring a character named Usasi and often touching obliquely on computer industry issues. In 1983, I wrote something like this:

I was sitting at my favorite table in Mister Bob's on Polk Street, explaining a fine forensic point to my associate Casey Standard and smart-mouthed lawyer Bette Noire. . . . Casey asked if we had heard of a programming case Mr. Usasi had in which a PROLOG expert system had been ported to a machine on which the values true and false had the opposite representation from what the programmer expected. Every true became a false, every full became an empty. Truth values were reversed universally. It was a real mess. Mr. Usasi was called in as an expert on expertise to advise them.

"Simple," I said. "Just reverse the interpretation of the output. You know, there was a clever database program on micros back in the 70s that looked a lot like expert systems of today, but was much simpler. You could tell it, 'Bartholomew's maiden aunt's Abigail,' and 'Bartholomew's birthday isn't February 29,' and ask questions like 'What's Bartholomew's favorite color?' It used Soundex coding. What was it called?

"Anyway, this all reminds me of that time in Guadalajara when I broke up a software smuggling ring that could have torpedoed the electronic spreadsheet market."

"That doesn't make any sense," Bette objected. "You don't have to smuggle software; you can just—"

"I'd insinuated myself into the smuggling ring," I went on, "a group of Orange County numerologists who had got it into their heads that balance sheets belonged to the masses and who were smuggling in spreadsheets to undermine the market leaders, which were Sorcim and VisiCorp back then.

"For deep and subtle numerological reasons, these Orange County spreadsheet smugglers had to divide the gold dust in which they had been paid into equal shares, with each smuggler getting exactly as many shares as there were smugglers who got shares, and with no undistributed shares.

"Now I had infiltrated the band and had studied a little numerology to beat them at their own game. I siezed on the fact that the smugglers secretly didn't want an even distribution of the spoils and suggested a scheme that would result in the same number of shares being distributed—which mattered to their numerological principles—and that would still allow an uneven distribution of shares—which appealed to the cupidity of the more powerful members.

"Give me exactly one share for each smuggler, I told them, counting me as one of the smugglers of course, and give each smuggler a different even number of shares, assigning them anywhichway. I gave them solid numerological reasons for the plan, and they bought it. I also stipulated, since I had demonstrated my value by coming up with the plan, that nobody get as much as twice my allotment, and they bought that, too."

Casey frowned at me. "I'm afraid this is a little far-fetched, Mickey."

"Sure it was," I explained patiently. "I was just playing along with them. I'm not into that numerological stuff. Anyway, after they solemnly agreed to the plan and swore their numerological oaths, they started divvying up the gold dust and discovered what I had pulled on them—but by then it was too late. Athough they didn't much like it, they had the integrity to stand by their numerological principles." I signaled for the check.

"That's the end?" Casey asked. "But what happened? What had you pulled on them?"

"Do the math," I said. "It's all in the math."

You can surely solve Mickey's little puzzle, but what about the upside-down expert system Casey mentioned? Because of its closed-world implementation, PROLOG does not treat true and false complementarily. What would happen if the base truth values in a PROLOG program were reversed? And what was the name of that database program?

Michael Swaine

Michael Swaine
editor-in-chief

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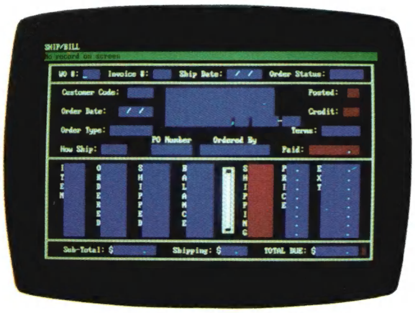

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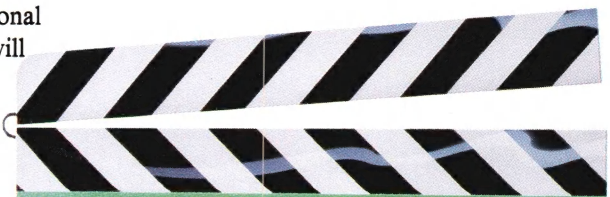

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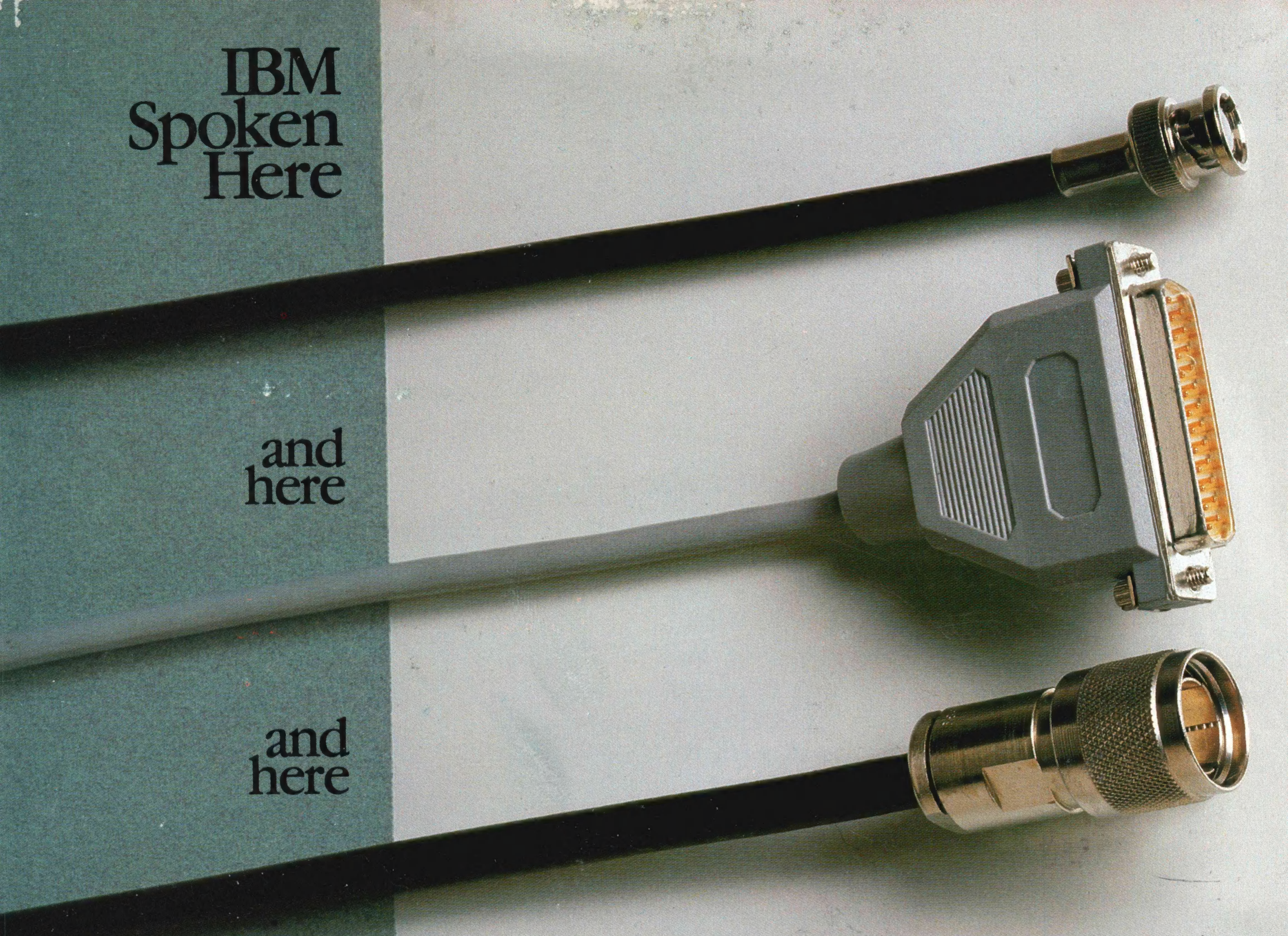

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